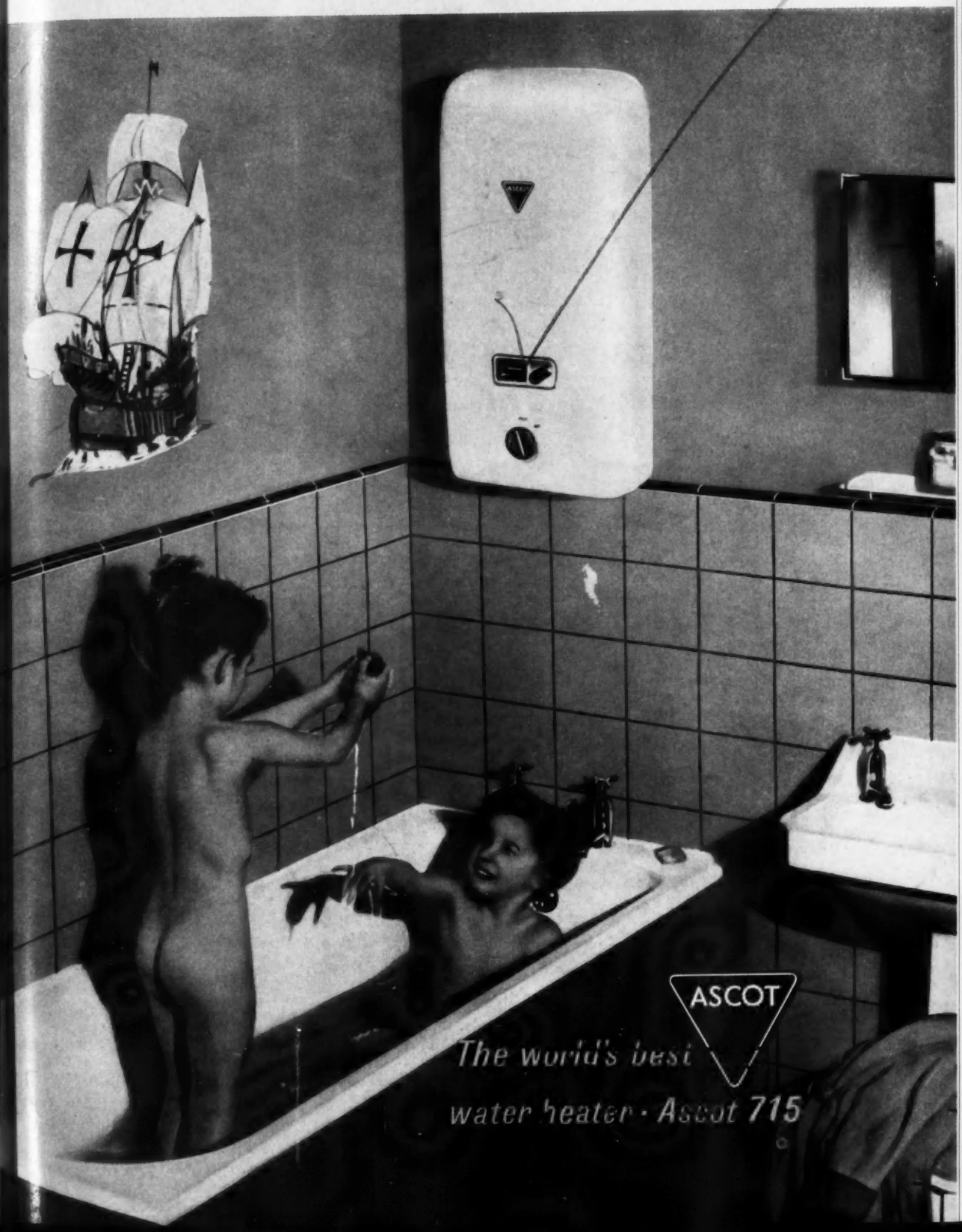
TECHNOLOGY DEPT.

Gas Journal

VOL. 277 106TH YEAR. LONDON, MARCH 17, 1954 NO. 4737. PRICE 1/3



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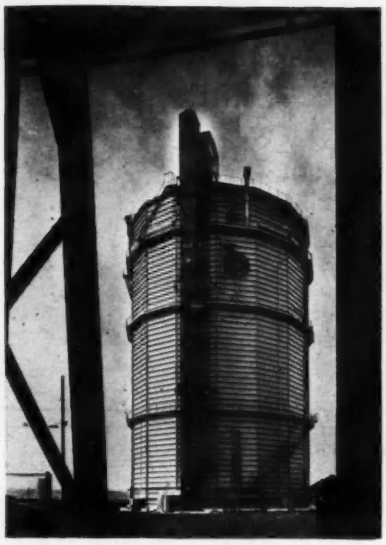

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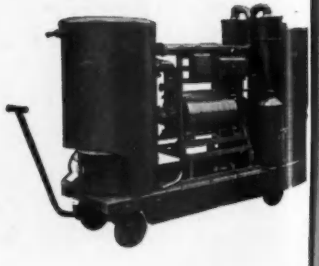

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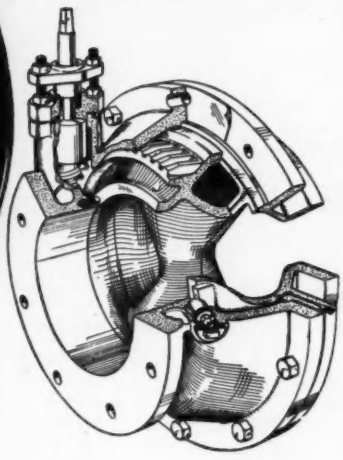

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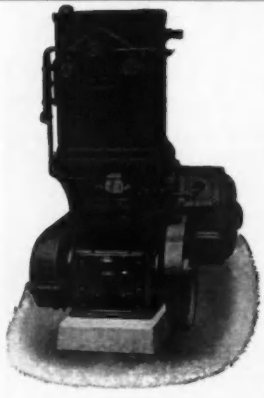

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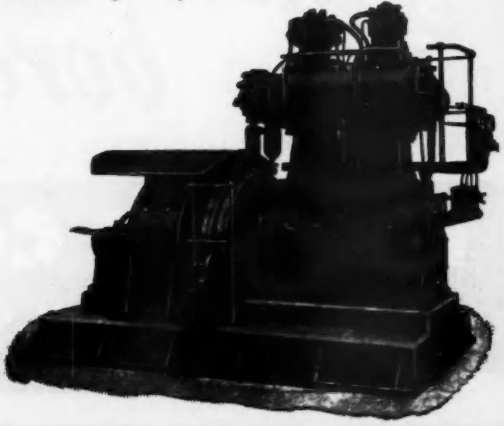

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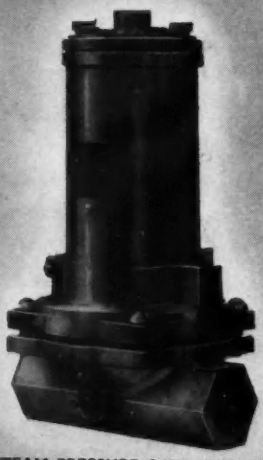
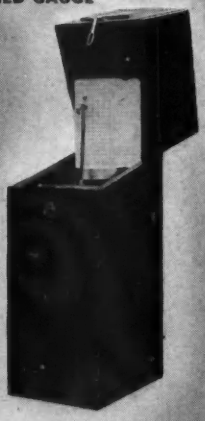
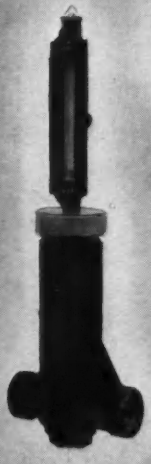


STEAM PRESSURE OPERATED GAS CONTROL VALVE

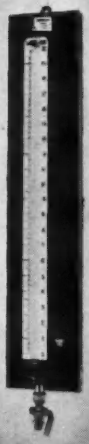
RELAY VALVE



PRESSURE RECORDERS



FLOW INDICATORS



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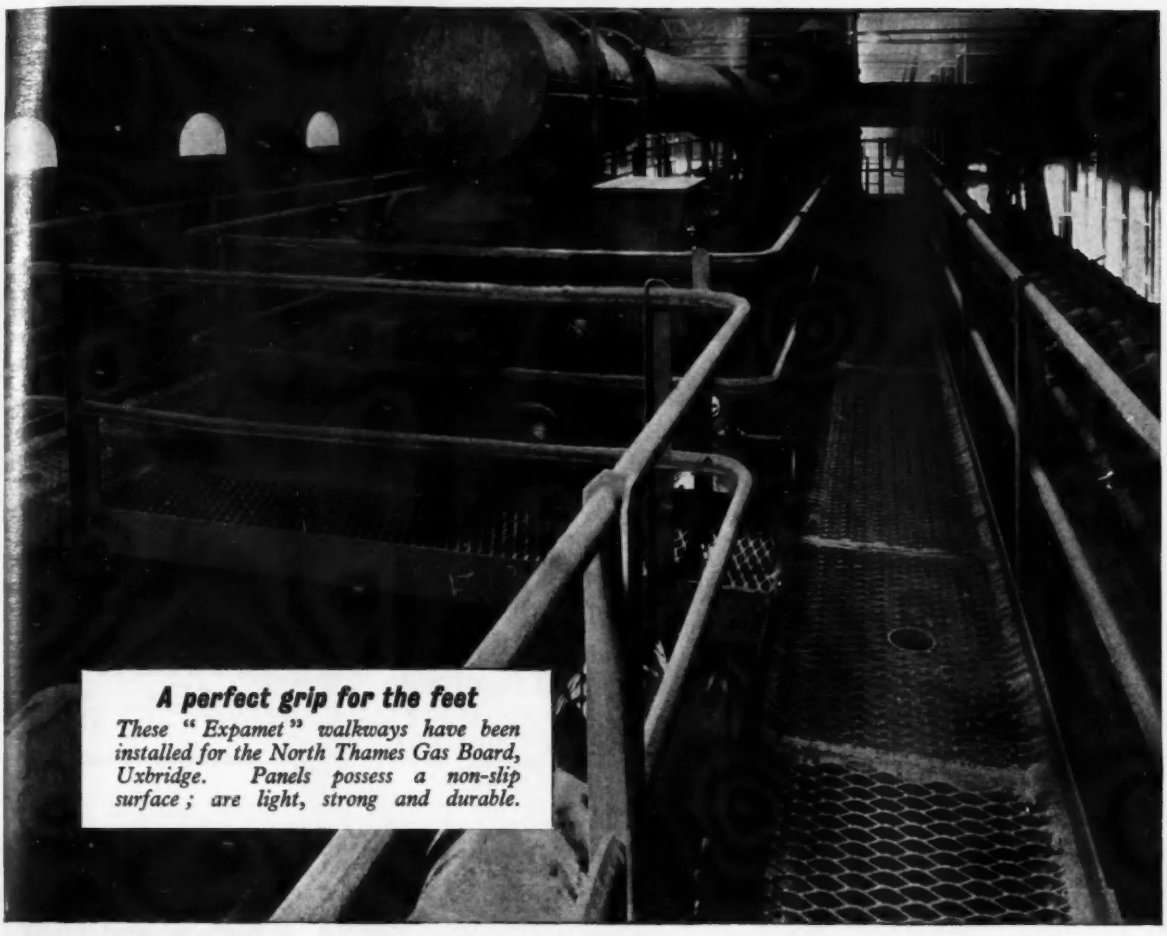

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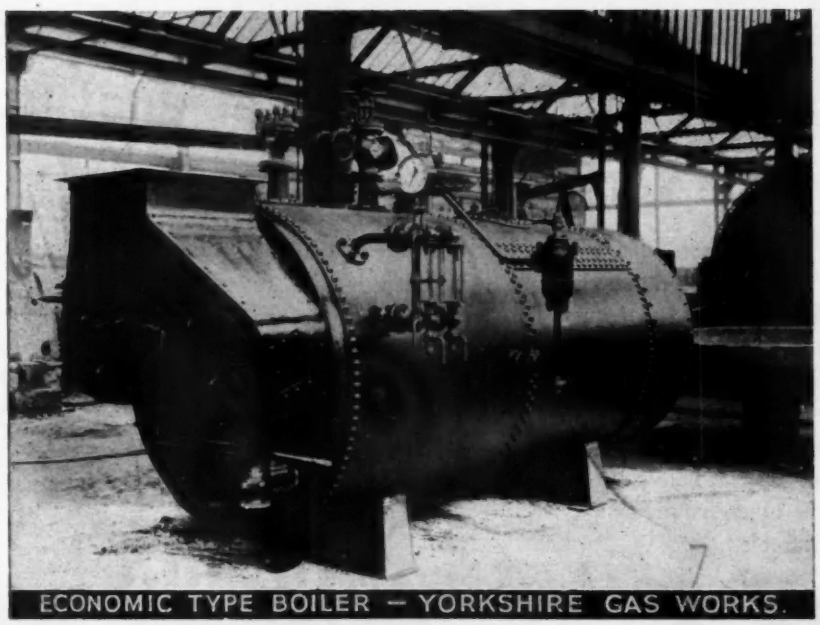

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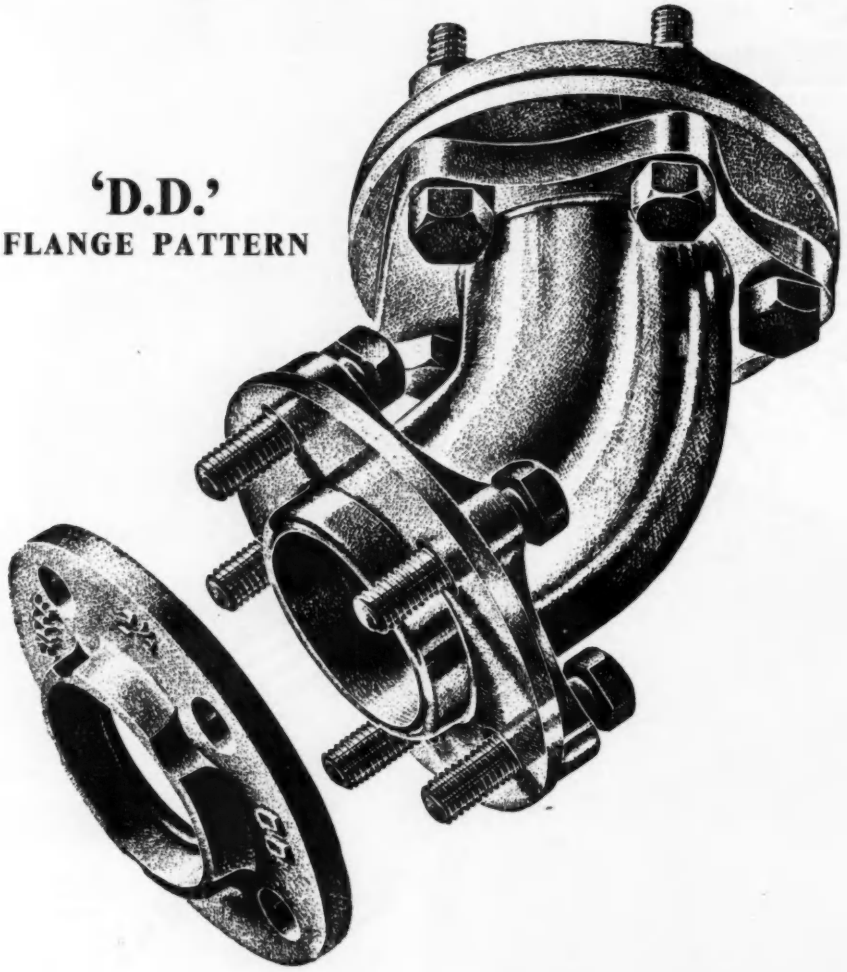

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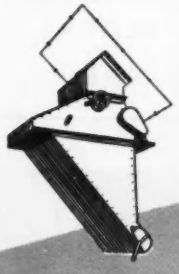

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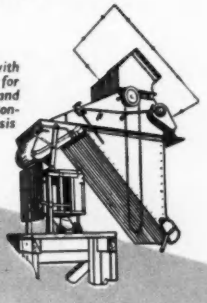

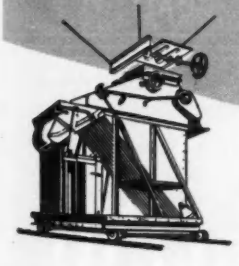

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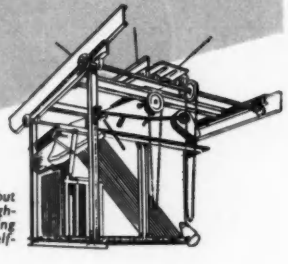

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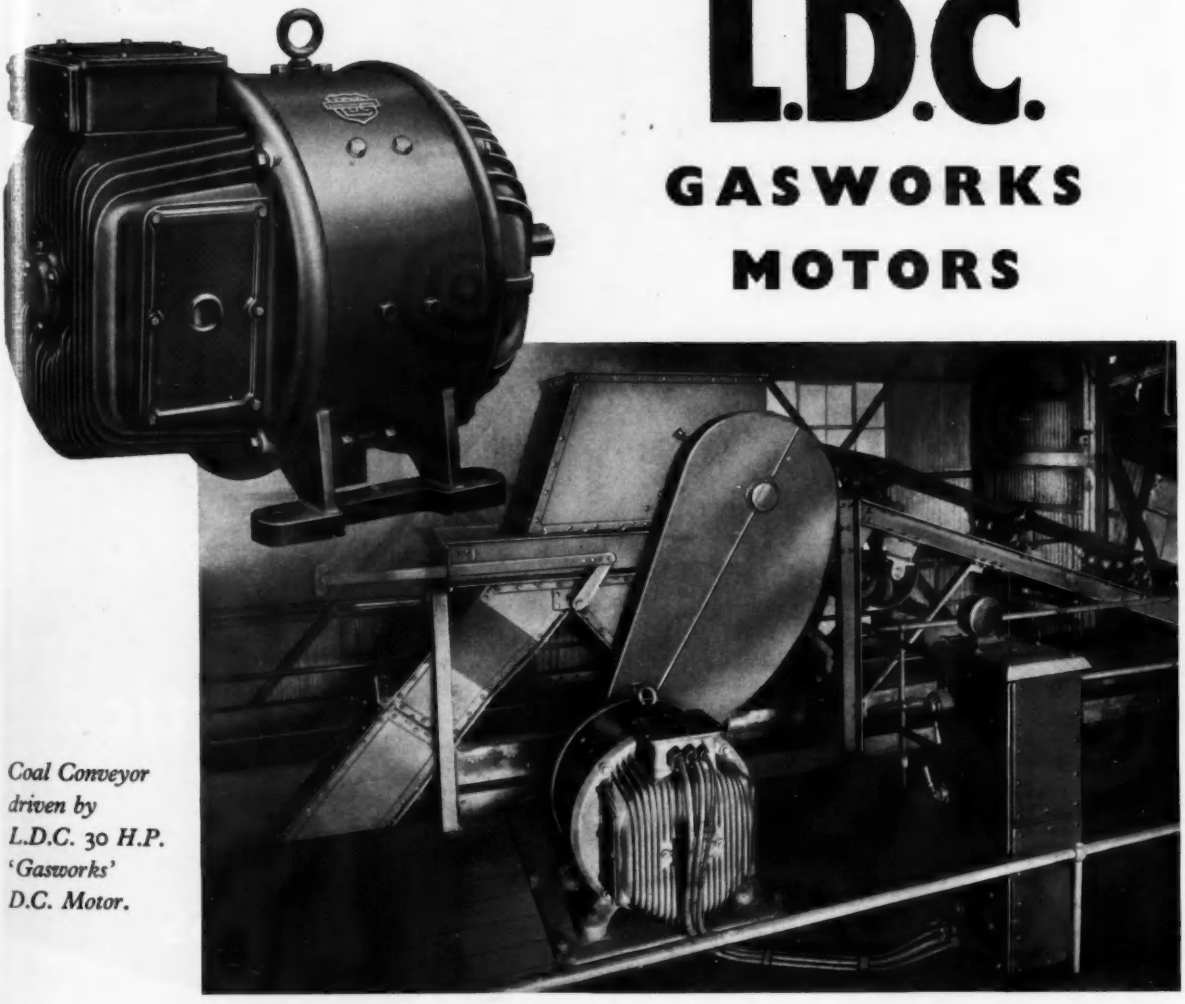

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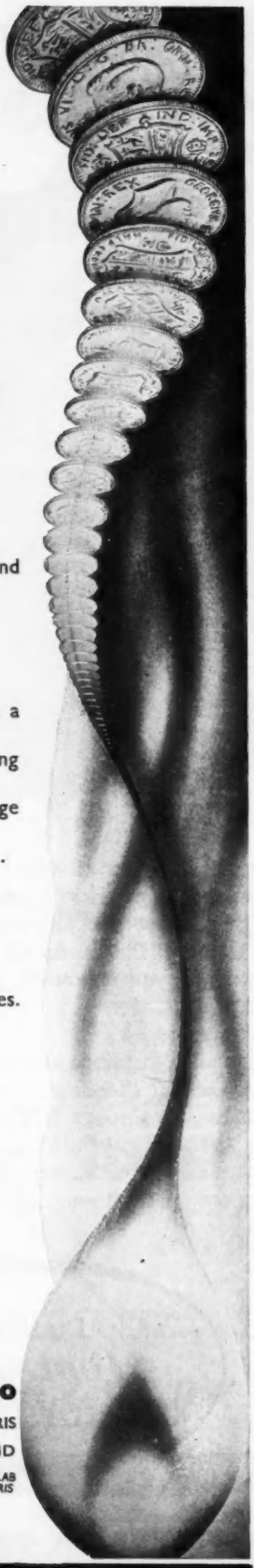

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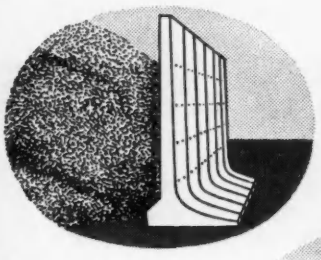

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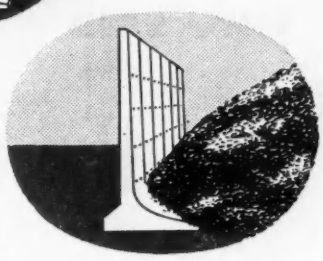

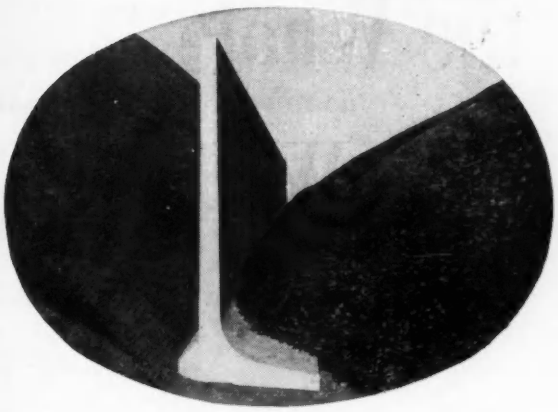

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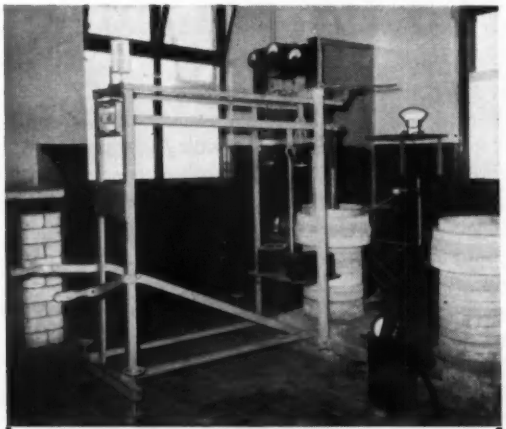

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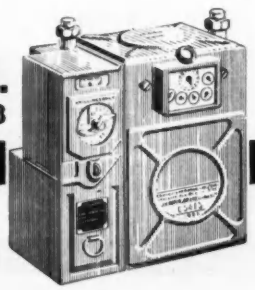

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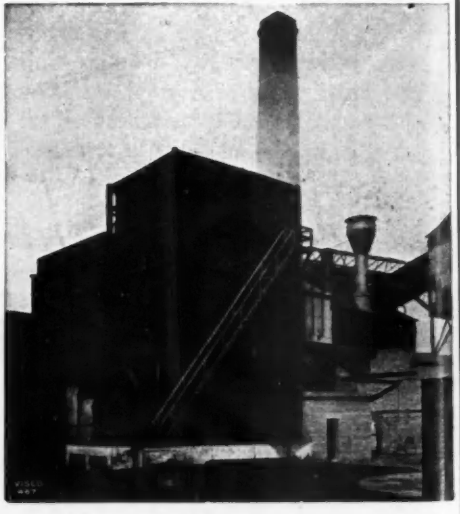

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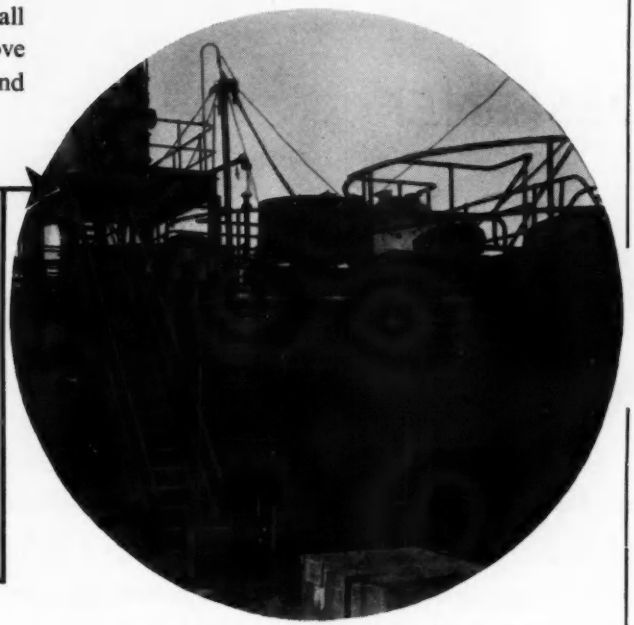
THE TANKS, THE SUPPORTING STEELWORK, the stair stringers, hand-rails and standards in this illustration have all been protected with DENSO TAPE, and over-wrapped with DENSELT TAPE to provide extra mechanical and dielectric strength.



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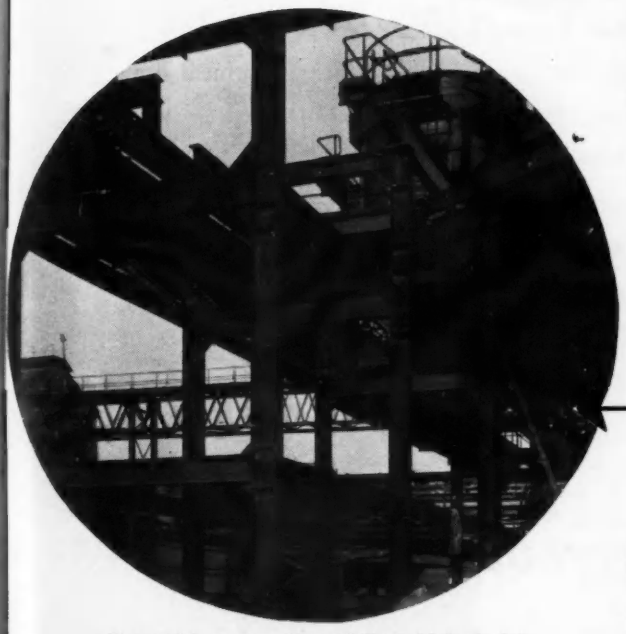

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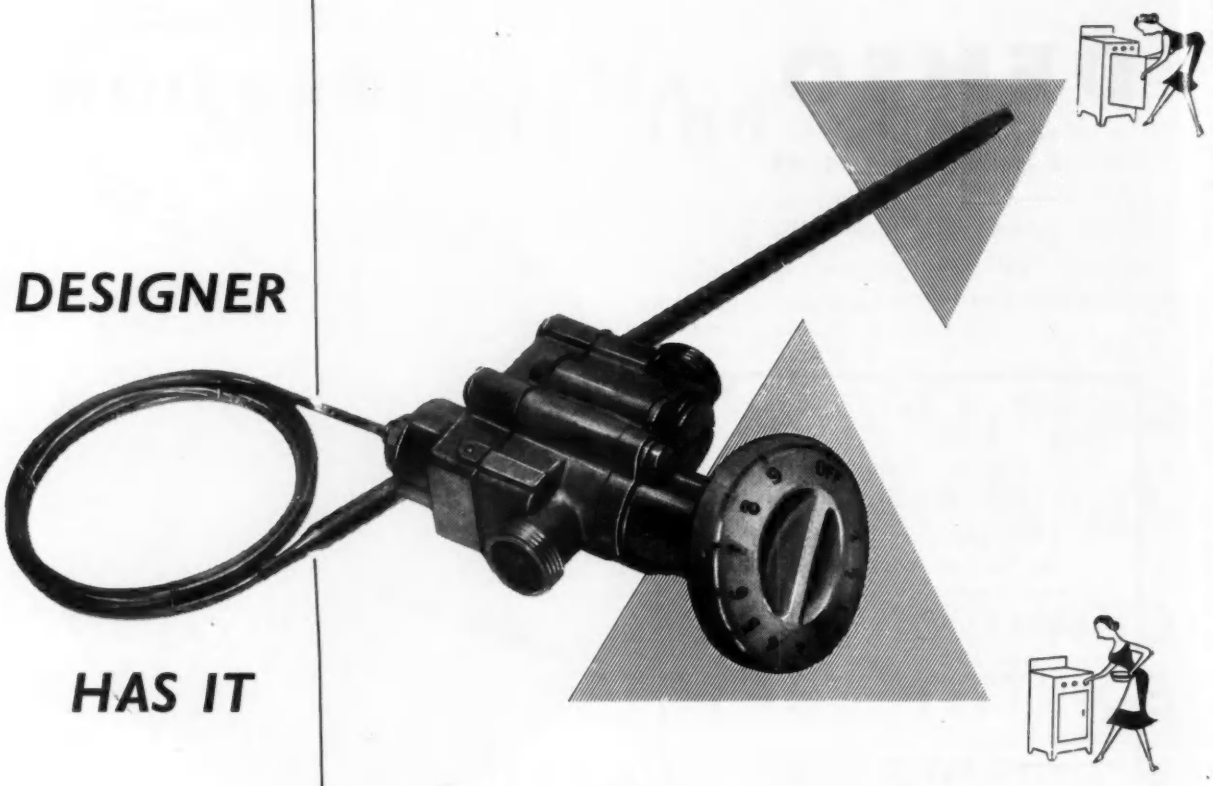

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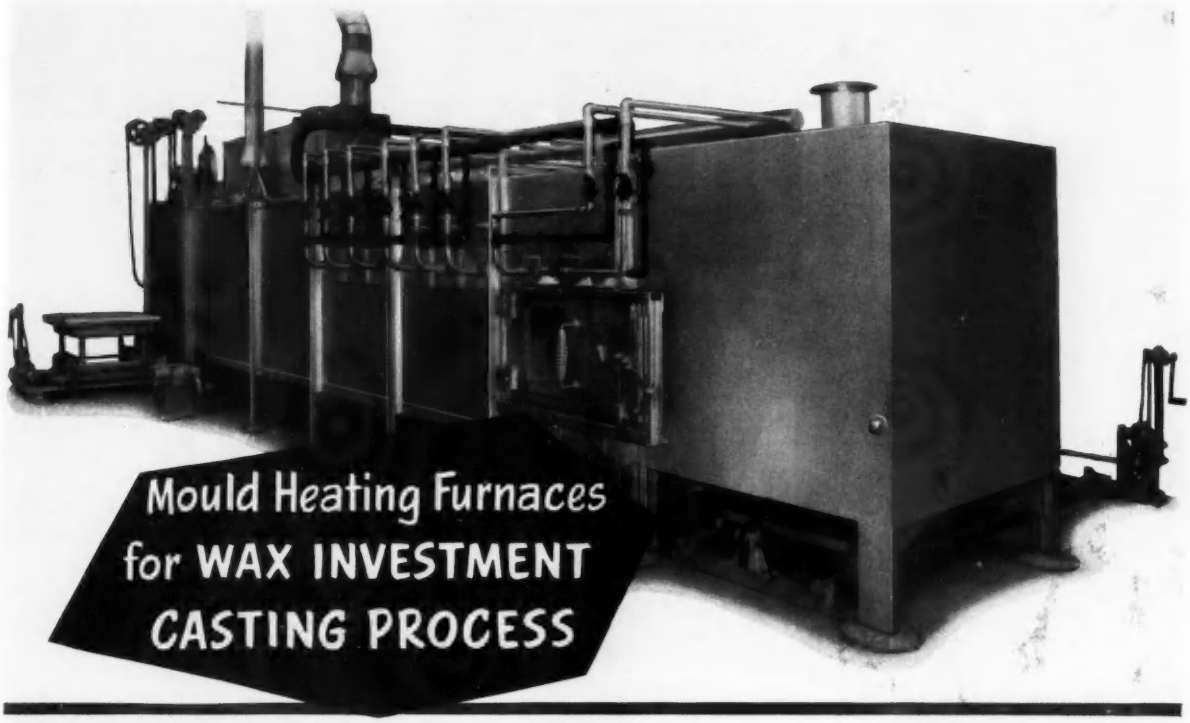

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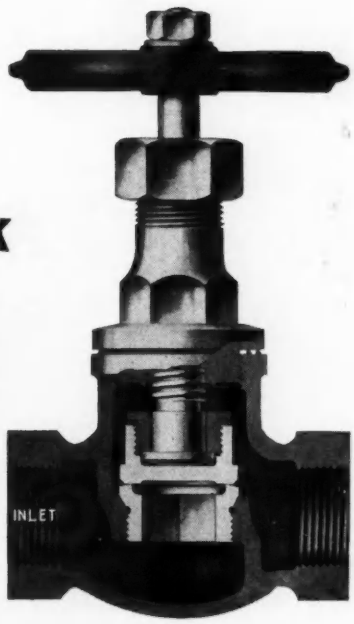

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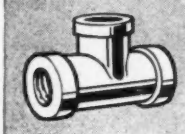

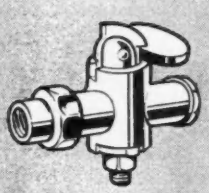

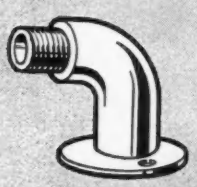

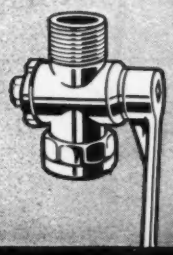

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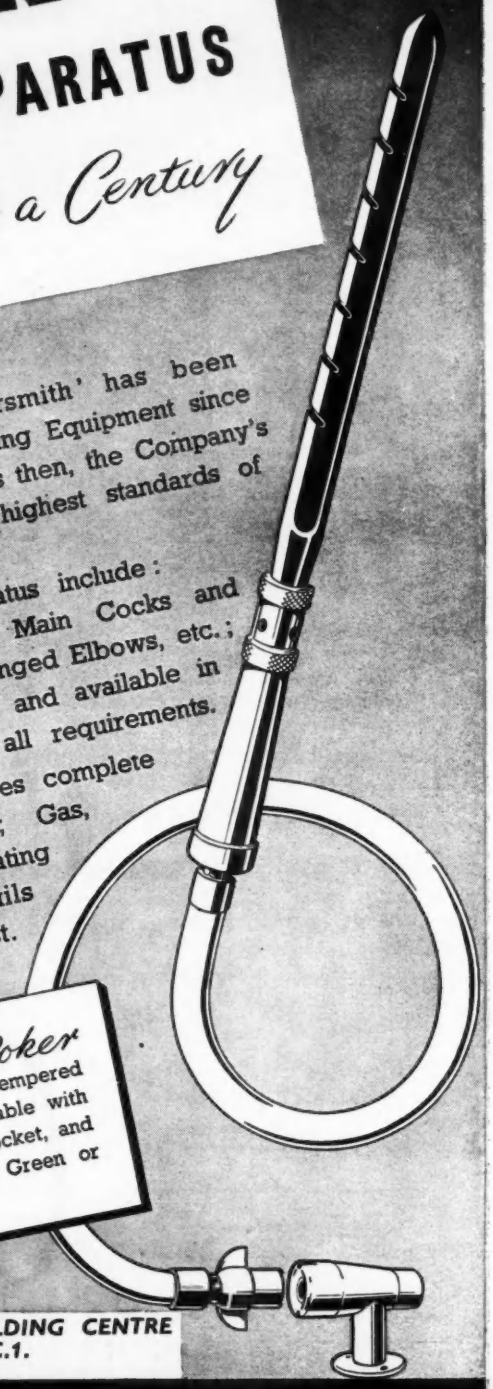

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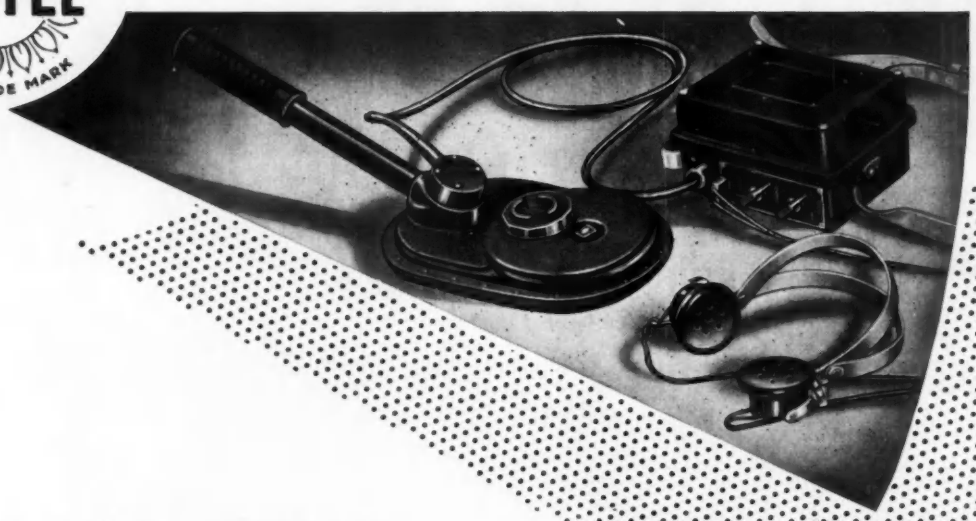

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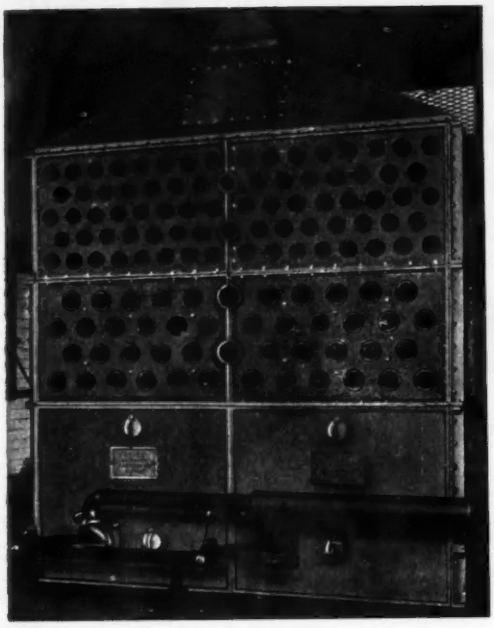

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106th YEAR OF PUBLICATION

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IT is strange how much thought and praise is given to true craftsmanship and how little to the craftsmen who carry it out. For instance, thatched cottages and ricks have long been part of traditional England, yet the thatcher whose skill has been passed down from father to son, through many generations, goes his way unrecognised and unpraised, except by the 'expert few' who know.

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Gas Journal

VOL. 277. No. 4737 106TH YEAR March 17, 1954

A 'REVOLUTION' IN CARBONISING?

First-rate publicity work brought the 'Rochdale' process to public notice on centre pages of *The Times*, the *Manchester Guardian*, the *Daily Express*, and other newspapers last Friday; and in the afternoon a packed audience, which included leading technicians from the Gas Council and other area boards, heard an able résumé of the paper by Messrs. Nicklin and Redman and entered into discussion in strictly professional vein. In this issue of the 'JOURNAL' we present paper and discussion practically *in extenso*. Our own first impressions follow.

It is not unusual for a 'new' and apparently successful development in technique to be seen as the revival of an old idea which for some reason or other was not pushed to its logical conclusion. There is generally no profit in attempting to answer the question 'Why did we not do this before?' But there is some interest in attempting to recall the economic and technical climate in which the original idea was conceived.

Mollwo Perkin and John West were searching about in 1917 for ways and means to increase the liquid products of carbonisation and, above all, as their patent claims show, to modify their composition in response to the demand for oil. But events were moving rapidly, and in the injection of steam they, and other workers, found an answer to a problem even more pressing, the production of greatly increased volumes of town gas per ton of coal at calorific values which were then being shown, for the first time, to be as suitable (to say the least) to the consumers' purposes as the higher values which had hitherto been deemed preferable. And not only higher yields per ton of coal but higher production per retort measured in useful gaseous therms per diem to the tune of 50% to 100%.

Nobody, re-reading the Fourth Report of the Gas Investigation Committee and the 1920-21 Report of the Fuel Research Board, 'Steaming in Continuous Vertical Retorts,' can fail to see a 'revolution' here, too. Nor will he fail to see that the injected steam and the water gas generated in the base of the retort was acting as a 'carrier gas'; there was internal heating as well as the added gas.

But steam was not only safe, convenient, and cheap as an auxiliary medium, it had *at that time* advantages over water gas generated in the plant then available. The water gas plant was not nearly so efficient as it is today. Roughly, it could be taken that 65 lb. of coke were consumed in the generator and in the production of steam to yield 1,000 cu.ft. of blue water gas; it was being done in the vertical retort for 15 lb. of coke. Another objection to water gas had a force which it is difficult for us to realise now; there was a fear of the insidious poisonous properties of carbon monoxide which even threatened to restrict steaming.

But the historian of gas supply will probably come to the conclusion that it was economic considerations—the state of the market—which caused steaming in the continuous vertical to dominate technical thinking in the years following 1918. Steaming had put carbonisation on the map as the most efficient means of treating coal. For the first time the gasworks process showed an overall thermal efficiency getting up to 90%. There was an unparalleled rush of work to make up for the complete cessation of building during World War I before which that following the last war pales into insignificance. And, frankly, it may be doubted whether constructors of the continuous vertical had time to think of anything else but how to satisfy the demand with existing designs.

The 'new' process will be subjected in the next few weeks to searching criticism—particularly on the aspect of the most suitable type of 'carrier gas.' And, as we have pointed out, the modern water gas plant with its waste-heat boiler and automatic mechanical operation is a vastly more efficient instrument than it was in 1920. But here Mr. Hawthorn has sounded a warning. The water gas plant will have to deal with the smaller grades of coke if it is not to skim the cream of 'coke for sale' upon which low gas prices so largely depend. Obviously the economics of the new process will need to be carefully worked out in many individual cases.

The possible advantages seem to be very great. They are well set out in the paper presented by Messrs. Nicklin and Redman to the Manchester District Section of the Institution, upon which they and the Section are to be congratulated. The impact of the new process on the design of the vertical retort and the plant employed to generate the carrier gas, as well as upon the following processes of wet purification and the disposal of liquor (and its quantity and properties) have still to be worked out. If, for one thing, it results in lower combustion chamber temperatures and less internal injury to the refractories of retorts it may well be worth while for that alone—provided, of course, that it also results in the securing of its main object, the cheaper therm.

RESEARCH AND ITS APPLICATION

'In the gas industry research is now receiving greater support than ever before.' No-one will quarrel with this assertion by Mr. W. K. Hutchison, Chairman of the South Eastern Gas Board, who addressed, in his capacity of Junior Vice-President of the Institution of Gas Engineers, a joint meeting of the Eastern and Western Districts of the Scottish Junior Gas Association on March 6 (see p. 690). Indeed, the latest research meeting of the Institution surely ranked as one of the best of its kind. Commenting on that meeting we said that scientists, young and not so young, already engaged in the industry are bringing keen intellects to the solution of a wide variety of problems, enjoying themselves in present achievements with no lack of plenty more to come. And we added that, if this aspect of the gas industry can be presented to the present generation of school and college leavers, there should be no difficulty in securing, what the industry must have, a steady recruitment of young technologists and technicians to carry on its work and maintain its place in the economy of the nation.

Since that meeting both the Institution of Gas Engineers and the Gas Council have published excellent booklets on the profession of gas engineering and the scope which the industry offers to keen, capable, and ambitious youth. And on p. 698 of our issue today will be found an announcement of the offer by the Gas Council of five research scholarships to graduates or prospective graduates tenable for a period of three years from September next at the Universities of Oxford, Cambridge, London, Birmingham, and Glasgow. The scholarships are sizeable (£350 a year, together with payment of university and college fees), and the investment should prove well worth while. The Gas Council is, of course, maintaining the close collaboration which has existed for many years with the Fuel Department at Leeds University—recognition of the need for background research deriving its strength from close university contact.

Himself an Oxford man and a research scholar, Mr. Hutchison directed attention to three stages—research, development, and design—through which it is necessary to pass on the way to the creation of new enterprises. We should not be discouraged, he emphasised, if from time to time theories have to be modified. Observations carefully made and accurately recorded (the answer to 'How?') double in value if they can be linked together and explained by theory. Even if theory (which seems to answer the question 'Why?') has in it the seeds of its own destruction, theory points the way to further possibilities capable of scientific test. Not only are such august teachers as Robert Boyle, James Clark Maxwell, Isaac Newton, and Osborne Reynolds referred to in name; they are also to some extent exemplified in deed, by Mr. Hutchison, who also aptly took the liberty to quote from Pope and Squire. There well might be, we suggest, a poetical-scientific society. The 'How' and the 'Why' of its establishment, and its terms of reference in general, we leave to others more imaginative than ourselves to determine.

We turn to the application of research. Our issue today is, in fact, quite a remarkable one. We have the erudism of Mr. Hutchison; we have the outstanding paper by T. Nicklin and M. Redman (a twin team already of considerable eminence) on accelerated continuous carbonisation, which, by the way, has rightly gained impressive publicity in the national Press; then we have an article by Dr. J. G. King, lately Director of the former Gas Research Board who, in direct terms, asks the gas industry to consider right away the application of proved research. Dr. King deals with the pioneer experiment which was conducted at Edinburgh by the late James Jamieson and himself during 1937. This showed without question that the gas industry could easily manufacture a reactive smokeless fuel with some sacrifice of gas yield, but without either building new plant or spending much money on modifications.

Since 1938, when the report of the experiment was discussed, the Edinburgh gas undertaking has made and still makes considerable quantities of this reactive coke under the name of 'Grancole.' No other gas undertaking in Great Britain has ventured to follow the example shown by Edinburgh. It is an example which, in Dr. King's view, demands the question 'Why?' He is certain that the National Coal Board would be glad to help the gas boards to provide more smokeless solid fuel by seeing to the supply of suitable coal grades in those areas where such coal is available. There can be little doubt that, given such coal, reactive fuel can be made on an economical basis.

Dr. King strongly recommends that the two national bodies concerned (the Gas Council and the National Coal Board) and the Ministry of Fuel and Power should look carefully into the question of supply of sized coals of N.C.B. types which, though outside the range of what we understand as gas-making coals, would provide immediately a solution, at least in part, to the fouling of our atmosphere by smoke. We add our own emphasis to what Dr. King insists in his timely article —that research should be applied, *without undue delay*, in practice.

THE LESSON OF FAWLEY

The manner in which the Fawley refinery was built for the Esso Petroleum Company has given British industrialists a serious jolt. Despite the fact that this enormous project—it cost £37,500,000—had unusual advantages such as unlimited dollars, ample supplies of raw materials, and Government backing, its successful accomplishment in two years still requires some explaining. Fortunately, the answers, or most of them, have been provided by the British Institute of Management, who have published a report by A. P. Gray and Mark Abrams on the 'Construction of Esso Refinery, Fawley,' which effectively emphasises the ways in which this undertaking differed from others in this country and indeed in the world, since we have no knowledge of any similar example of American technicians controlling British labour on such a complete scale and with such mutual satisfaction. It is clear that we have something, perhaps a lot, to learn from the report. Though it would be difficult and perhaps undesirable to attempt to emulate the exact conditions obtaining at Fawley, it should be possible to undertake certain experiments in industrial relations based on this pattern.

The success of the achievement appears to us to have been built on two main pillars. One was (to us) the quite extraordinary degree of planning, which started two years before the job was due to begin and was of such a concentrated and detailed nature that the exact

progress to be achieved day by day during the estimated two-and-a-half years of construction was plotted in advance. The other pillar was the practice of a form of industrial psychology which, though somewhat allied to the more advanced methods practised in this country, was nevertheless unique in its informality and, paradoxically, in its rigid discipline. Between these pillars was built an arch of mutual trust, technical skill, and common purpose which throughout the entire operation kept the structure rigid and reliable.

The planning technique employed will be studied by many in this country whose work lies in that direction, but we are probably not alone in thinking that of the two main components of Fawley's success, industrial relations is the more interesting. When it is considered that over 5,000 British workers were employed at the site and in two years there was not one serious stoppage of work due to labour disputes, it is obvious that more than good luck was responsible. What, then, was the secret?

The greatest importance must be attached to the fact that most of the work went to one large contractor (the Foster Wheeler Corporation with its British subsidiary) and all labour was engaged under one contract and with one body, the Confederation of Shipbuilding and Engineering Unions. There was one unified system of wages, with no piece rates. Stewards on the site received a sympathetic hearing if stating a grievance, but if the matter could not be settled on the spot it was immediately referred to the area officials of the union and the stewards' responsibility was terminated. Dismissal threatened any steward who left his work, without written permission, to deal with union affairs. By this means the authority of the union officials was enhanced and the relationship between the union and the employers was smooth and cordial.

DEMOCRACY IN PRACTICE

It is inevitable that such a happy state of affairs owes much to the personality of individuals. Throughout the story of Fawley the personality of one man, the American project manager, looms strongly. Mr. Bob Cole—'Bob' to almost everybody—is revealed as a man of striking character and ability, and there are many amusing stories of his acute powers of perception, his unfailing command, and his humanity. Informality was certainly one of the outstanding characteristics of the whole relationship between the project manager, his satellites, the Standard Oil engineers who spent most of their time out on the site, and the men themselves. It is significant that the presence of a large number of supervisors and 'field checkers' in no way antagonised the men, primarily because they treated the men as equals, worked at least as hard and as long as any man under their control, and genuinely knew their job. Their attitude was aptly summed up by a young pipefitter: 'They muck in, and an English foreman would not do that.'

We have already suggested that the project did not lack money—money for lavish welfare arrangements and first-class equipment. Sceptics may perhaps use this as an argument for belittling the extent of the achievement at Fawley. But money alone could never achieve the degree of team spirit which suffused the whole operation. That was due, in the main, to the factors we have mentioned, plus the fact that elaborate arrangements were made to keep the men informed of progress and to induce a feeling of joint endeavour.

The co-partnership attitude is not unknown in British industry and certain companies have achieved much in establishing a co-operative attitude towards progress and prosperity. But we think we are correct in suggesting that such arrangements usually obtain in factories and works which tend to have an unchanging staff and are engaged in what might be termed 'continuous operation.' The creation of a spirit of co-operative effort in an isolated construction job, albeit a large and fairly long-term one, is surely something new in our experience. It proves that it can be done and that the men do not necessarily consider that it is in their interests to spin the job out. Fawley was finished three months ahead of schedule.

We hope that British industry will seek to put into practice some of the lessons learned from these American high-productivity methods. Some of them may apply to the gas industry, for there is no reason to suppose that private enterprise alone is capable of such heights. But let us pray that the day is far distant when we shall hear the retort house stoker refer to his area board chairman as 'Charlie.'

OUR SISTER 'GAS SERVICE'

Congratulations on a big and excellently varied March issue, featuring in particular the Ideal Home Exhibition. H.R.H. Princess Margaret, on her private visit, graces the front cover, where she is seen listening to Mr. Warrenne's explanation of the Gas Council's model village of period houses. A special eight-page art supplement deals with gas industry exhibits. Youth's semi-final cooking fling has two pages. Outdoor heating is discussed and profusely illustrated in the light of recent developments—a very useful summary in view of slightly hysterical paragraphs which have appeared lately in some daily and weekly papers. In this regard we strongly commend G.W.B.'s cartoon on p. 142.

N.W.G.B. AND 3-D SALESMANSHIP

It can be said that the North Western Gas Board team are always 'on the ball'; and when, prior to the Manchester meeting last Friday, we called on Mr. J. W. Rodgers, the Sales and Service chief, we found him speculating on the possibility of cheaper gas and coke from the Rochdale process and enthusiastic about the up-to-date way of selling those commodities. The medium is '3-D,' handed across by the salesman in a neat box of stereoscopic colour transparencies with viewer complete. Mr. Rodgers' pilot scheme will fit up 50 to 60 salesmen and saleswomen with the apparatus, primarily for a cooker campaign; and the field of battle lies in the very considerable areas of housing development around Manchester, where, in general, local authorities have agreed to freedom of choice by their tenants as between gas and electricity. The stereoscopic stock-in-trade will be pairs of slides of cookers—one view cooker closed, the other loaded and in full action, steam and all if you like—so that the housewife can see precisely what meal can be conveniently cooked. The appeal of this '3-D' presentation is almost irresistible. We know, because our own Photographer has been on it for the past six months.

NOTE.—The greater part of this issue is devoted to the paper by Messrs. Nicklin and Redman (on 'Accelerated Carbonisation; Rochdale Process') and the subsequent discussion. The type will be kept standing and reprints will be available, should sufficient demand be forthcoming.

Personal Notes

MR. ARTHUR A. LEONARD, engineer, manager and secretary of the Ironbridge (Salop) District of the West Midlands Gas Board, is retiring at the end of the month, having completed nearly 50 years in the gas industry. He went to Ironbridge in 1920 as Engineer, Manager and Secretary of the Ironbridge Gas Company, having previously been assistant engineer and manager at Nuneaton. During his service at Ironbridge, Mr. Leonard has seen the amalgamation of the small undertakings at Madeley, Broseley, Dawley and Much Wenlock with Ironbridge and the inter-connection of mains with Wellington, which was completed in 1947-1948. Last December Mr. Leonard was presented with a long-service award for over 40 years' continuous service in the gas industry. Mr. Leonard commenced his career with the Aldershot Gas and Water Company in 1905, and served with the Woking, Grays, Tilbury and Nuneaton gas companies before going to Shropshire.

Mr. J. H. SHADBOLT, who was appointed Station Engineer designate, Portslade Works, South Eastern Gas Board, last August, took up his appointment as Station Engineer on March 1. He began his career in the gas industry with West's Gas Improvement Co., Ltd., in 1922, and after three years' pupilship, was employed until 1933 on their erection and operating staff. For the next six years he was Carbonising Supervisor with the Liverpool Gas Company at the Linacre Works, and in 1939 was promoted to Assistant Engineer at the same works, a position he held until 1945. He joined the Brighton, Hove and Worthing Gas Company in 1945 as Assistant Gas Engineer.

Mr. H. V. CORFIELD, M.I.MECH.E., M.INST.GAS.E., Manufacturing and Mechanical Engineer, Brighton undertaking, Sussex Division of the South Eastern Gas Board, has retired. Mr. Corfield's long association with the gas industry began in 1904 when he joined the South Metropolitan Gas Company at Old Kent Road. He remained at Old Kent Road until 1918, during which time he was successively draughtsman and clerk of works, chief assistant to the constructional engineer, and operating engineer of the phenol recovery plant. He then went to the East Grenwich works as Chief Assistant Engineer and completed the last year of his service with the South Metropolitan Gas Company as engineer of the Vauxhall works. In 1919 he became assistant engineer to the Brighton and Hove General Gas Company, and succeeded to his present position of Manufacturing and Mechanical Engineer in 1935. By the end of February, 1954, when he retired, he had completed 50 years with the gas industry.

MR. T. HOLMES JOHNSON, Scottish Representative of Parkinson and Cowan Gas Meters, was married at Hyndland Parish Church, Glasgow, on March 6, to Miss Vynne Lee.

MR. J. F. COURTNEY, senior salaried auto meter inspector in the Belfast Corporation Gas Department, has been appointed supervisor of the meter section, thus filling the vacancy caused by the death of MR. W. L. CARLISLE.

MR. E. J. DICKINSON, M.A., B.SC. (Oxon), F.R.I.C., of the Bituminous Binder Research Unit of the African Council for Scientific and Industrial Research, has been appointed Scientific Assistant to the British Road Tar Association. He served as a Secretary of the Road Tar Research Committee (the joint Committee set up under the co-operative arrangement between the B.R.T.A. and the D.S.I.R.) from 1950 to 1951. He has spent the last two years in Pretoria studying the use of the locally produced bituminous binders under the more exacting climatic and unusual traffic conditions there, and has carried out an investigation into the rôle which sunlight plays in the changes which occur when a bituminous binder is exposed on the road.

MR. S. R. MARFLEET has been appointed Sales Manager for the gas equipment side of the business of the Harris Engineering Co., Ltd. He has been in the gas industry for 17 years, and after service with the Lea Bridge and Tottenham undertakings he became an industrial sales engineer with the North Western Gas Board.

MR. A. C. BURDEN, MR. N. C. A. SPURGEON, and MR. E. W. SWALES have been appointed Deputy Managing Directors of the Automotive Products Co., Ltd., and asociated companies. MR. E. BEAUMONT (Production), MR. S. M. PARKER (Engineering) and MR. S. WESTWOOD SMYE (Purchasing) have been appointed Executive Directors to deal with specialised activities. MR. J. B. EMMOTT has been appointed to act as an Alternate Director to any member of the Board.

Obituary

MRS. M. RICHMOND, the widow of the late Frank Dean Richmond, who was well known in the gas industry in Yorkshire and Lincolnshire, has died at Harrogate in her 83rd year.

MR. GEORGE CRAVEN HOLLIDAY, B.A., M.INST.GAS E., F.INST.F., Manager of Watson House since 1950, died suddenly on March 7, aged 53. After serving in the 1914-18 war and obtaining his Honours Degree in chemistry at Oxford, Mr. Holliday entered the Gas Light and Coke Company in 1923. Starting at Beckton works as an assistant to the works chemist, he subsequently held a variety of posts. As senior assistant to the chief gas chemist, he helped in initiating the Fulham Research Laboratory, where he spent five years on research on gas manufacturing problems. He was transferred in 1929 to the general manager's department and occupied various administrative and technical posts, including that of the joint secretaryship of the South Eastern Gas Corporation during its formative period. He was also secretary of the Patents Committee and secretary of the Works and Products Committee. In 1937 he was appointed Assistant Chief Technical Officer, Watson House. From 1945 to 1950 he was Manager of the Gas Light Centre. After nationalisation, the Gas Light Centre became the Watson House Centre, of which all gas boards are members. His administrative and technical ability found expression in the guidance given to the various committees over which he presided. During his career he served on many gas industry and other national committees, and was a Gold Medallist of the Institution of Gas Engineers as a joint author of a paper given in 1945.

COUNCILLOR A. T. MORRISON, Chairman of the Scottish Gas Consultative Council and a former Aberdeen City Treasurer, has died at his home at Aberdeen. He was about 70 years of age and had served for 22 years on Aberdeen Town Council and was the second longest serving member.

MR. STEPHAN SIMPSON, who has recently died in Devon, aged 84, had taken a leading part in developing the gas industry and the Exeter firm of Willey and Co., of which he was Chairman. A native of Mansfield, Mr. Simpson came of an engineering family which had made meters since 1820. He carried on the family tradition, and his inventiveness helped to revolutionise the meter industry. The patentee of many specialities, he devised most of the automatic and other machinery used by Willey & Co. Mr. Simpson leaves a son and two daughters.

Correspondence

SURFACE COMBUSTION BURNERS

DEAR SIR,—I have no intention whatever of pursuing this matter further, but I must correct a statement in the first paragraph of an article in your issue of March 3 entitled 'More about the Schwank Burner.'

As you are no doubt aware, we have been making surface combustion burners for over 30 years and there are thousands in use all over the world for industrial work, 70% of which are operating in an inverted—that is, horizontal—position without in any way affecting the efficiency of combustion.

Yours faithfully,

A. DOCKING,
Managing Director.

Radiant Heating, Ltd.,
Barnsbury Park, N.1.
March 9, 1954.

SMOKELESS FREE-BURNING FUEL

'The Production of Free-Burning Coke in Continuous Vertical Retorts'

(J. Jamieson and J. King, I.G.E. 199/83, 1938)

By Dr. J. G. KING, O.B.E.

The wide publicity which is now being given to atmospheric pollution, and the work of the Committee on Air Pollution of the Ministry of Housing and Local Government which is now sitting to consider means for mitigating pollution, have redirected attention afresh towards the possibility of increasing the manufacture of solid smokeless fuel.

It is being said that new processes of manufacture are required and that research must be expedited, but one feels bound to ask whether either is really necessary. It is true that a more flexible fuel than gas-retort coke is wanted if household coal is to be replaced successfully and without compulsion, particularly if the introduction of the coke oven into gas manufacture spreads, but surely it would be wiser to look carefully at past work before launching a new, and no doubt expensive, campaign of research.

The existing annual supplies of smokeless fuel other than coke oven or gas retort are approximately:

	Tons
1. Anthracite	2,300,000
2. 'Phurnacite'	180,000
3, 4. 'Coalite' and 'Rexco' ...	370,000

The first can probably not be increased at present. The second may be limited by supplies of Welsh carbonaceous slacks, but in any case expansion of supply would mean the construction of new plant. This is also true of processes 3 and 4, but the latter in particular could readily be expanded in certain areas since its preferred feed stock is weakly-caking sized coal, of which there are plentiful supplies in the Midlands and in Scotland.

A procedure to which I wish particularly to redirect attention, however, is one which does not call for the construction of either new carbonising plant or new works. It is the modification of use of the continuous vertical gas retort to produce a sufficiently reactive coke.

A Proved Process

I refer to the operation of this form of gas retort at a somewhat lower temperature of carbonisation and on sized weakly-caking coals. A pioneer experiment was conducted at Edinburgh by the late James Jamieson and myself during the year 1937, which demonstrated clearly that the gas industry could readily manufacture a reactive smokeless fuel with some sacrifice of gas yield but without either building new plant or spending money on modifications other than separate screens. The only, but important, requirement, is a supply of suitable coal.

A report of the experiment was discussed at the 1938 annual meeting of the Institution of Gas Engineers and was received with general approval, but, although Edinburgh has, ever since, made and sold considerable quantities of 'Grancole' (1,500 tons per annum), no other gas undertaking has ventured to follow. I feel quite sure that, with the present emphasis on a cleaner city atmosphere the National Coal Board would be glad to help the gas boards to provide more solid smokeless fuel by providing suitable coal grades in those areas where such coal is available. The Edinburgh experience has shown that, given suitable coal, a reactive fuel can be made.

In the Jamieson/King experiment the coal used was of a type which is plentiful in certain areas and which may be described in general terms as weakly-caking bituminous coal with a Gray-King index of D to E, and containing 39% to 43% of volatile matter in the dry, ash-free coal. It is therefore in class 800 of the coal classification system of the National Coal Board and is outside the range normally used in gas manufacture. The size grades used were doubles and trebles of approximately 1¼ in. to 1 in. and 3 in. to 1¼ in. in range respectively.

The gas retorts used consisted of one unit of four standard Woodall-Duckham 75 in. continuous-vertical retorts (1926) with lambent heating, equipped with a separate gas-collecting system for experimental work. After preliminary exploration of the effect of temperature and throughput the test work was conducted at a temperature of 1,250°C. (top) to 950°C. (check tile) and a throughput of 8.5 to 11.2 tons per retort per day, as against the normal figures for Scottish gas coal of 1,380°-1,100°C. and 8.5 tons per day. It was intended that, when using 13% of steam, the coke would contain 4% of volatile matter, but still be uniformly carbonised and show no smoke on combustion. This was fully realised.

The sacrifice of gas yield was appreciable, but the gas was of higher calorific value than the normal 475 B.Th.U. per cu.ft.

	Tons per retort per day	Gas per ton therms	Gas C.V.	Gas per retort per day, therms
Normal	8.5	76.0	476	646
Test	8.5 to 11.2	52.0-60.0	520	533
% difference ..	+7	−25	—	−17

	Coke, cwt.	Tar, gal.
Normal	13.1	15.4
Test	12.1	16.2
% difference ..	−8	+5

The coke proved to be sufficiently strong and hard and to have adequate ease of ignition and free-burning properties for use in the open domestic fire. It was also very suitable for domestic stoves and in this case could be used down to a size of ¼ in.

During carbonisation the coal particles remained separate, but intumesced sufficiently to show an appreciable increase of size. This is demonstrated in the mean size analyses of coal and coke.

Size, inches	over 2	2-1½	1½-1	1-¾	¾-¼	¼-0
Coal, per cent.	0.9	10.5	42.3	26.2	19.2	
Coke, per cent. ..	10.8	21.8	36.7	12.3	18.0	9.8

It is apparent that the sizing of the coal had not been sufficiently careful to exclude undersize material, and it would be interesting to know what would happen with coal free from undersizes. In the 'Rexco' process, where the temperature of carbonisation is lower, and there is degradation of size, the proportion of material below ¼ in. is not as much as 15% from Top Hard coal of type D.

It is also possible that coal of type E, or even F, would give equally reactive coke; it would give enhanced yields of gas.

In view of these satisfactory results it is suggested that consideration should be given to possibility of applying this procedure widely and of doing so now without waiting for the unknown results of further research.

The Economic Aspect

On the question of economics it could be said that the procedure is not favourable to the gas industry when considered from the point of view of a gas-making process, but on the wider national question of providing a new large supply of smokeless fuel without new capital expenditure, and by integration in an existing organised industry with its own facilities for handling and sale, it has possibilities which should be carefully reviewed at the present time. It is clear that the price obtainable for the fuel must be higher than that obtainable for

normal coke in order to compensate for the loss of thermal yield of gas. It is understood that the difference in Edinburgh is only 2s. 6d. per ton, but this is not enough in view of the high price of 172s. commanded by 'Coalite' and the 104s. paid for normal coke. An intermediate figure of, say, 150s. should compensate fully.

On the important question of coal it is clear from the N.C.B. 'Plan for Coal' that large tonnages of coal of the right type are planned for production in Scotland, Northumberland, and the South Midlands. The question at issue is what proportion of these could be made available for this purpose in a 1-3 in. grade of reasonably low ash content, say, 4%-5% in the coal, or 6%-7% in the smokeless fuel.

The coal is classified by the N.C.B. in group 800, but within this group there are appreciable variations of caking power and it would be necessary to ensure that the Gray-King coke type was not lower than type C/D and was preferably type D or D/E. In Scotland splint coals of this type, and in the Midlands durain coals or 'hards,' tend to contain shale bands which, when wetted, give to coke the undesirable quality of sparking, sometimes quite violently, in the open fire. If the fuel is intended for the open fire such coals would have to be avoided; the property would be less objectionable in stove fuels.

Finally, therefore, I would strongly recommend that the two national bodies concerned (Gas Council and Coal Board), and the Ministry of Fuel and Power, should look very carefully into the question of the supply of sized coals of N.C.B. types 800 and 700 and this very simple application of the use of the continuous vertical gas retort.

A ROYAL OCCASION

The Duchess of Kent accompanied by her son, the Duke of Kent, and Lord Rothermere, stop to admire a new gas oven, a feature of which is its eye-level grill, at the Cannon stand at the Ideal Home Exhibition at Olympia. Mr. A. F. Oatley, Chairman and Managing Director of Cannon, has the honour of explaining to Her Royal Highness the outstanding features of the cooker.

Institution of Gas Engineers

Manchester Section Meeting

There was an abnormally large attendance at a meeting of Manchester and District Section of the Institution of Gas Engineers at the Central Library Theatre, Manchester, on March 12, when the main item on the agenda was the presentation of a paper on 'Accelerated Continuous Carbonisation (Rochdale Process),' by Mr. T. Nicklin and Mr. M. Redman, Production Engineer and Assistant Production Engineer respectively of the North Western Gas Board. (See pp. 665-686.) Mr. A. K. Collinge (Preston), Chairman of the Section, presided, and at a luncheon at the Café Royal prior to the meeting he extended a cordial welcome to Mr. J. T. Haynes, President of the Institution; Mr. D. P. Welman and Dr. R. S. Edwards, Chairmen of the North Western and North Eastern Gas Boards; Mr. Bernard Clarke, Chairman of the Eastern Section, I.G.E.; Dr. W. T. K. Braunholtz, Secretary of the Institution; Mr. K. L. Stock and Mr. A. Wilson, of the Ministry of Fuel and Power; Mr. C. Johnson, Coal Officer, Gas Council; and Mr. Clifford A. King, Editor of the 'GAS JOURNAL.'

He also welcomed the following specially invited guests: Messrs. W. A. Evetts and E. H. Winch (Eastern Gas Board); W. R. Branson, F. G. Pyper, and D. W. Ault (East Midlands); W. F. Thorne (Southern); T. W. Clapham and J. Parker (South Western); W. R. Garrett and J. E. Dixon (Northern); S. K. Hawthorn, H. Moys, S. C. Porter, and E. T. Pickering (West Midlands); S. L. Wright (Wales); D. G. Elgin (Scottish); and A. H. Savill (South Eastern).

The Chairman referred sympathetically to the death of Mr. W. Hill (Sandbach), a member since 1905; Mr. F. G. Shaw (Blackburn, formerly of Buxton), a member since 1911 and President of the former Manchester and District Association in 1934; and Mr. F. A. West (Altrincham), a member since 1935. The resignation of Mr. J. H. Noble (Chester), a member since 1917, was also reported.

The following new members were welcomed: T. Albone (Civil and Structural Engineer, North Eastern); F. C. Barker (Deputy Chief Engineer, North Eastern); K. H. Brown (Principal, Preston Training College); T. W. Pickthall (North Cheshire Group); F. T. Scantlebury (Oswaldtwistle); E. W. Stevenson (Principal, Stretford Training College); and D. B. Stokes (Blackburn)

It was announced that the annual general meeting would be held on April 30.

Diary

March 20.—YORKSHIRE JUNIORS: 'Use of Liquefied Petroleum Gases for Town Gas Enrichment,' J. G. Gaunt, Deputy District Engineer and Manager, Spenborough. At Sheffield.

March 22-26.—FACTORY EQUIPMENT EXHIBITION.—Horticultural Hall, Westminster. Gas Council Exhibit.

March 23.—MIDLAND JUNIORS: 'Integration Problems.' F. L. Atkin. Staff Mess Room, Council House, Birmingham.

March 24.—MANCHESTER JUNIORS: Joint Visit with North Western Salesmen's Circle to Stoves, Ltd., Rainhill.

March 25.—NORTH THAMES G.C.C.: Caxton Hall, Westminster.

March 27.—SCOTTISH JUNIORS (WESTERN): Visit to Granton Gas Works, Edinburgh.

April 1.—MIDLAND JUNIORS: President's Day, Stourbridge, 10.30 a.m.; luncheon, Wulfrun Hall, Wolverhampton, 12.30 p.m.

April 6.—'YOUTH IN THE KITCHEN' final. Royal Festival Hall.

April 6.—SOUTH EASTERN G.C.C.: Caxton Hall, Westminster. 11 a.m.

April 7.—LONDON JUNIORS: visit to B.C.U.R.A., Leatherhead.

April 7.—YORKSHIRE JUNIORS: Visit to Metropolitan Meter Works, Nottingham.

April 8.—EASTERN SECTION, I.G.E.: Visit to Lincoln Gasworks.

April 9.—LONDON JUNIORS: Manufacturing Paper by M. S. Gaskell, Technical Director, West's Gas Improvement Co., Ltd., 178, Edgware Road, W.2. 6.30 p.m.

April 10.—SCOTTISH JUNIORS (EASTERN): Paper from an industrial representative.

London Craftsmen have completed a minor, yet essential, operation for the maintenance of the plant which washes flue gas at Battersea power station. They have fixed 95,400 quarry tiles in the tower where the gases are washed to remove sulphur compounds, and they have taken 30 tons of cement up to 150 ft. aloft in doing the job. Each tile has been fixed to its concrete base by Semtex, Ltd., with their bonding cement containing pure rubber from the Dunlop plantations. The tiles are specially jointed with a cement even more resistant between the joints.

YOUTH IN THE KITCHEN—Area Finals

Finals of the 'Youth in the Kitchen' competition will take place in London on April 6. Meanwhile, results of three more area finals are to hand. Joan Comley, 17-years-old student at Hendon Technical College, whose home is at Enfield, won the North Thames Gas Board area final. Her supremacy was over an original entry of 3,500 in the Board's area. Runner-up was Shirley Trott (19), a Chalfont St. Peter girl and a member of the 'Under 20's Club,' Gerrards Cross. Third place was taken by 15-years-old Pauline Turner, Forest Gate.

Captain Michael Ward, the successful Everest expedition's medical officer, presented the prizes and novel competitions were held to entertain the 1,000-strong audience. A 'magic show' followed, featuring first-class magicians who disposed of surplus onlookers by sawing them in half and causing them to vanish.

Miss Rosemary Hume and Miss Muriel Downes, the Principal and Assistant Principal, respectively, of the Cordon Bleu School of Cookery, were the judges. The Chairman of the Board, Mr. Michael Milne-Watson, C.B.E., announced the winners. In the photograph (right) are Shirley Trott (2nd), Joan Comley (winner), and Pauline Turner (3rd).

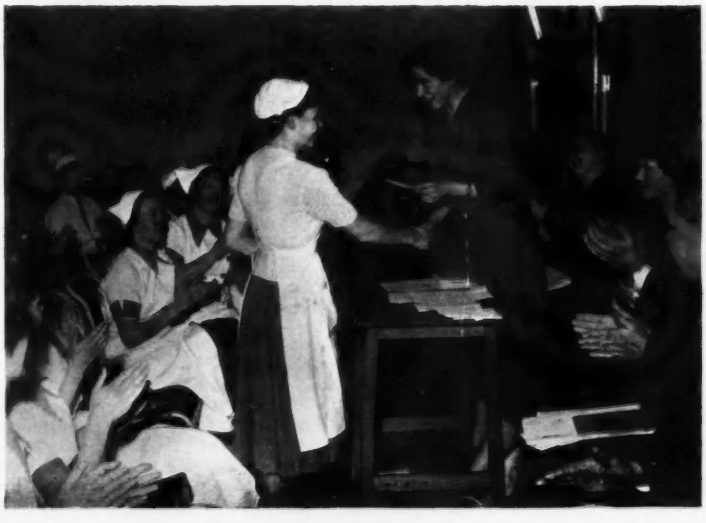
Miss Mollie Kierce, of Castleford (Wakefield Group), earned the distinction of representing the North Eastern Gas Board at the national finals when she won the area final at Leeds. The competition was well attended by an audience representative of every age group, and Dr. R. S. Edwards, Chairman of the Board, welcomed Dame Vera Laughton Mathews and Miss Patricia Cutts, of television fame, who presented the prizes. The judging was undertaken by Miss J. M. Keeling, Inspector of Domestic Science for Leeds Education Department, and Miss M. Blackburn, Head of the Domestic Science Centre of Huddersfield Technical College, and while this was being done, two short films were shown. First place was given unanimously to Miss Kierce, second and third going to Miss Popplewell, of Bradford, and Miss Johnson, of York.

When presenting the prizes, Miss Cutts promised to arrange a visit to Lime Grove Television Studios for the six area finalists, who Dr. Edwards had previously announced were to be invited to attend the national final as guests of the Board. The picture (left) shows Patricia Cutts tasting the winner's delicious apple amber.

The Wales area final took place at Cardiff on March 3 when 15 competitors from all parts of Wales met to decide who should have the honour of representing Wales in the national finals. The honour fell to Juliet Grier Rees, of Ferryside, Carmarthenshire, finalist from the Swansea Group. The victory of Miss Rees brings further honour to an already distinguished family, for her brother, Midshipman Nigel Rees, was selected by the Duke of Edinburgh to be his page at the Coronation.

Representatives of the B.B.C. and the national and local press were in attendance as well as a large number of representatives of various civic and public bodies. The judges were Miss E. Davies, H.M. Inspector of Schools for Domestic Subjects and Mrs. E. Baker, Senior Lecturer in cookery at the Training College of Domestic Arts, Cardiff.

The prizes were presented by Miss Jennifer Cox, a young student elected by the students and staff of the Bakery and Catering Department of the Cardiff College of Technology and Commerce. The youngest Cardiff home service adviser, Miss Elizabeth Donovan, was chairman. Our photograph (right) shows Lady Collins, Lady Mayoress of Cardiff, chatting to competitors.



WELDED ALUMINIUM TIPPERS

Ten tipper bodies recently completed by Anthony Hoists, Ltd., for the North Thames Gas Board mark another step forward in the development of construction techniques for road haulage vehicles. These bodies, five of which have a capacity of 9 cu. yards and the remainder a capacity of 4 cu. yards, are of aluminium construction, welded throughout by means of 'Argonaut' shielded-arc welding equipment. This process, adopted for the first time in this country for body-building, enabled the fabrication to be carried out on a semi mass-production basis.

Experience in welding techniques for light alloy bodies was gained by Anthony Hoists, Ltd., some time ago when the firm built a single 4-cu. yard tipper body that was used by the North Thames Gas Board for hauling coke, breeze, oxides, and other materials. The success of this body encouraged its users to specify similar construction for a new fleet. The new bodies are fabricated entirely from aluminium sheet and plate supplied by Northern Aluminium Company, Ltd., with the exception of tailgate fittings and short splash-boards, which are of steel.

Specification

The 9-cu. yard bodies, which measure 10 ft. 6 in. × 6 ft. 10 in. × 3 ft. 5½ in., are of generally orthodox fixed-side square design. Floors are of flat ¼-in. 'Noral' 54S plate, and have fillets of 8 in. radius running the full length at each side, ensuring clean tipping. Floor bearers are of 10 S.W.G. sheet formed into top-hat section, and side pillars are of the same material in the form of channels. Side, front and tailgate sheets are also of 10 S.W.G. 54S, but for the top rails thickness is increased to 8 S.W.G. Transverse reinforcing strips of angle section provide additional stiffness for the front sheets, which are also supported by two ties welded to the floor.

The five bodies of 4-cu. yard capacity differ dimensionally from the larger bodies in height, being 1 ft. 6½ in. high instead of 3 ft. 5½ in. Otherwise their construction is essentially similar, except that 'Noral' 54S sheet of 8 S.W.G., swaged longitudinally for extra rigidity, is used for the floors, and there are no internal fillets. Rear cornerposts for both sizes of body are of extruded equal angle, extended below the level of the side rave and gusseted, and short lengths of similar angle are used to secure the body to the tipping sub-frame. In all the bodies precautions were taken to prevent galvanic corrosion by applying a protective paint between steel and aluminium where they came into contact.

Rapid Construction

The 'Argonaut' welding process that made the rapid construction of these bodies possible is of the consumable-electrode type, in which aluminium wire (in this case 'Noral' 54S) is fed continuously into the weld, fusing in an envelope of inert argon gas. The equipment was supplied by Aluminium Laboratories, Ltd.

Weldability was among the first considerations in the choice of alloy for the bodies; 54S successfully meets the requirements in this respect, and has adequate strength and high resistance to corrosion. This last quality is of particular importance in this application, for the loads of coke, breeze, and oxides that the bodies are expected to carry have an abrasive and corrosive nature that causes rapid deterioration of less durable materials. The scouring action of the load on the floor continually removes corrosion products and exposes a fresh surface to attack, and under such conditions only a material such as aluminium, with an inherent resistance to corrosion, can be expected to have a long life. The adoption of welded joints throughout, moreover, has the effect of increasing resistance to corrosion, since riveted joints, which can provide the starting points for attack, are completely eliminated.

All-welded construction for light-alloy bodies is still an innovation in this country, and like all new developments it must prove its worth—and its advantages over existing methods—before it can be considered an economic proposition. The Northern Aluminium Company suggests that, as experience with the new techniques is gained, and confidence in the performance of bodies built in this way grows, we may expect that this method of manufacture will soon be regarded, not as a novelty, but as a logical way of meeting and overcoming the particular problems encountered in the design of bodies for tippers that operate under adverse conditions.

Illustrated here is the 4-cu. yard body in the tipping position.

'S. & L.' Steel Pipes for Gas

From Stewarts & Lloyds, Ltd., of Glasgow, Birmingham, and London, comes a lavish catalogue beautifully bound, profusely illustrated, using the art of colour-printing to good advantage, and running to well over 200 pages. In this catalogue will be found all particulars normally required for 'S. & L.' steel pipes for gas, together with relevant technical data. The previous edition of the catalogue was published in 1938. In the present edition are the alterations in standard outside diameters and thicknesses of the pipes and in the formulæ for calculating flow.

Efficiency in steel pipe manufacture requires standardisation of sizes on the smallest number within a given range compatible with efficiency in use. An amendment to B.S. 534 has therefore been issued reducing considerably the number of sizes and thicknesses from those in the 1934 edition. To obtain economy in steel, the minimum thickness of pipe suitable for the required working conditions should be used. Modern surface protections make it perfectly safe to do this. The firm's protective products have been the subject of intensive research. They are applied under strictly controlled conditions, and they provide a most effective means of resisting corrosive attack on the pipes either internally or externally.

With gas pipes, internal protection required depends on whether the gas is or is not subjected to drying treatment at the source. Experience has shown that for the conveyance of dry gas an anti-corrosive protection is unnecessary. But the firm supplies pipes protected internally with a coating of pure boiled linseed oil, unless other protections are specified.

External protection is admirably treated in this remarkable catalogue, in which it is explained that sheathing can be applied to pipes 3 in. bore and larger. The pipes, after being coated, are covered with a mixture of bitumen and short asbestos fibres. There are three stages in the application of this protection. The pipes are first coated; then they are covered with hot bitumen about 3/64 in. thick; and finally the protection is completed by wrapping spirally round the pipes a layer of dried and chemically treated hessian cloth, impregnated with bitumen. Security wrapping can be applied to pipes up 16 in. outside diameter. These protections constitute an effective safeguard against the most corrosive soil conditions and are capable of withstanding normal handling, in transport or at site.

*

	Installation		tons per day
ADELAIDE (Aust.)	1st	–	80
	2nd	–	100
	3rd	–	160
	4th	–	75
BRIGHTON (Aust.)	1st	–	60
	2nd	–	20
	3rd	–	28
	4th	–	58
	5th	–	58
	6th	–	58
	7th	–	58
CHRISTCHURCH (N.Z.)		–	150
FREMANTLE (Aust.)	1st	–	20
	2nd	–	20
	3rd	–	10
	4th	–	30
	5th	–	30
GEELONG (Aust.)	1st	–	60
	2nd	–	20
	3rd	–	20
	4th	–	20
	5th	–	40
	6th	–	40
IPSWICH (Aust.)	1st	–	20
	2nd	–	13
LAUNCESTON (Aust.)	1st	–	20
	2nd	–	10
	3rd	–	10
MELBOURNE (Aust.)	1st	–	160
	2nd	–	160
	3rd	–	160
	4th	–	160
	5th	–	160
	6th	–	160
	7th	–	160
	8th	–	160
	9th	–	160
	10th	–	160
PERTH (Aust.)	1st	–	80
	2nd	–	40
	3rd	–	165
PORT PIRIE (Aust.)		–	22
SYDNEY (Aust.)	1st	–	210
	2nd	–	210
	3rd	–	210
	4th	–	210
WANGANUI (N.Z.)	1st	–	20
	2nd	–	40
WOLLONGONG (Aust.)	1st	–	36
	2nd	–	12

*

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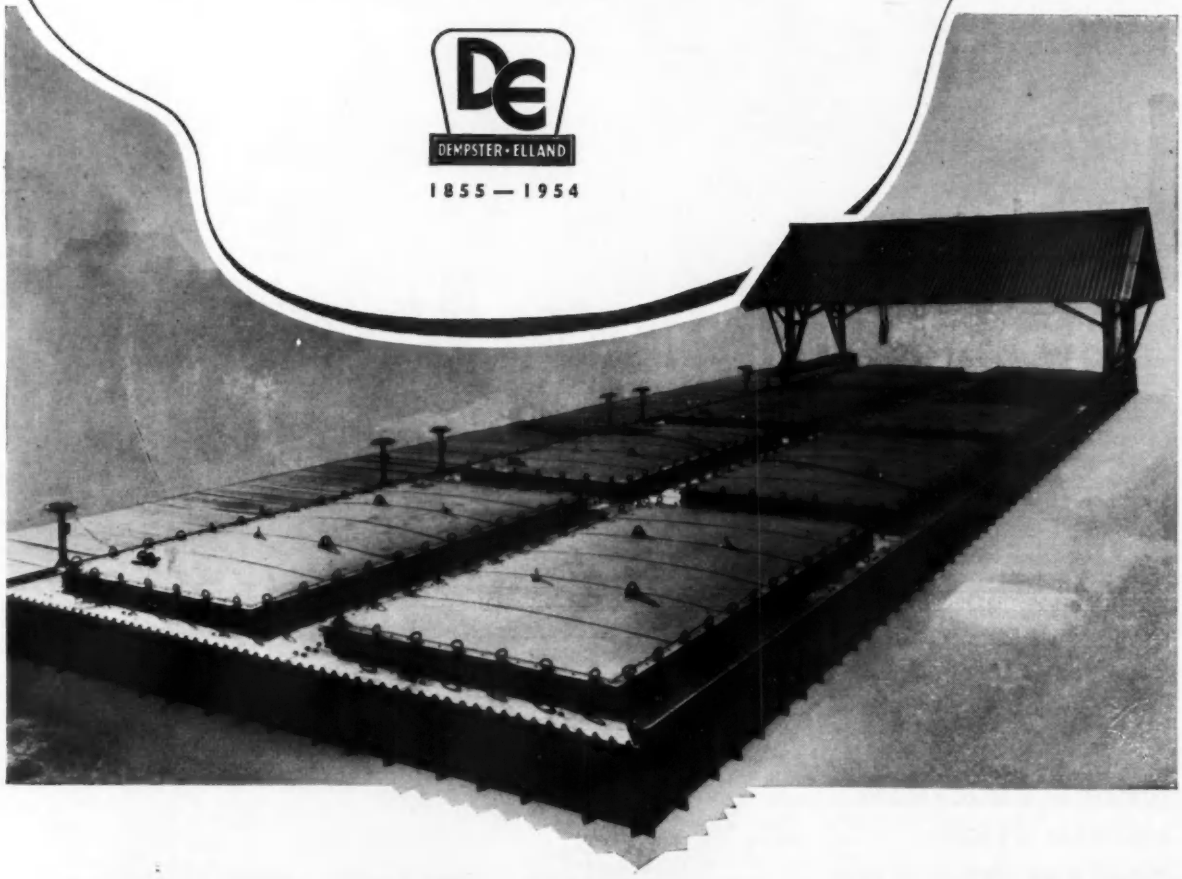

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Accelerated Continuous Carbonisation

THE 'ROCHDALE' PROCESS

A PAPER TO THE MANCHESTER AND DISTRICT SECTION OF THE INSTITUTION OF GAS ENGINEERS ON MARCH 12, 1954, BY

T. NICKLIN,

M.Sc., M.Inst.Gas E., A.M.I.Chem.E., Production Engineer, and

M. REDMAN,

B.Sc.(Tech.), A.R.I.C., Assoc.M.Inst.Gas E., A.M.I.Chem.E., Deputy Production Engineer, North Western Gas Board.

In this paper, methods of gas production are reviewed in the light of production costs. The need to reduce these costs is shown and the contribution offered by integration of gas manufacture is noted. Further reduction could be made if productivity could be increased from existing assets in the form of production plant. Examination of existing gas-making methods suggested that this could be achieved in the case of continuous vertical retorts, which constitute some 70% of the coal gas capacity of the North Western Gas Board. The paper describes a new technique of coal carbonisation and deals in some detail with the results which have been achieved on pilot scale trials. Considerably increased speeds of carbonisation are shown to be possible, more than double the conventional rates being realised. The effect of this increased productivity is examined in relation to production costs, capital expenditure, size and quality of coal, coke quality, and plant flexibility. The conclusion is drawn that the process shows promise of yielding the desired reduction in production costs and of increasing flexibility.

Introduction

The gas industry has operated, over the past 15 years or so, under rapidly changing conditions which are still showing little tendency to stabilise. It has had to face substantial increases in the cost of raw materials, in labour and maintenance charges, and in the cost of new plant. Moreover, the delivery of new plant, though now improving, is still protracted and is often the cause of inconvenience and means maintaining uneconomic production plant in operation longer than is desirable.

In these circumstances, the planning of a future gas production policy is essential in order to ensure that adequate supplies are available at the right places at the most economic production cost. The task, however, is not an easy one since, by the time a new plant is in operation, economic circumstances may have changed to a degree that renders the original conception uneconomic. It is essential, therefore, to plan with flexibility in mind as the most important consideration. In practice, this means that the combination of production plant should be flexible in regard to the raw materials it can use and the relative quantities and qualities of products which it yields, and that the integration system which serves it should enable this flexibility to be fully realised. The work described in this paper may lead to greater increase in such flexibility than is at present attainable, and this has obvious advantages.

At this juncture it is appropriate to review the present changing economic background as it affects gas manufacture and Table I shows the approximate current costs of producing base load gas in 4 mill. cu.ft. per day units at a calorific value of 450 B.Th.U. per cu.ft. under price conditions at present operating in the area of the North Western Gas Board.

The first interesting point that emerges from examination of this Table is that, in the case of projected new plant—where capital charges must be taken into account—carburetted water gas may be produced at least as cheaply as coal gas, whereas the net cost (*i.e.*, without capital charges) of coal gas remains somewhat below that of C.W.G. This tendency has been reported by Burns and Clark[1]. In existing plant, therefore, where capital charges are fixed and net costs must rule the method of operation, it is economic to produce coal gas with the given prices of materials. The use of heavy oil for enrichment and lower-priced smaller grades of coke bring the net cost of C.W.G. very near to that of coal gas, however, so that expansion of water gas production potential is obviously indicated. There is, however, a limit to the proportion of this gas that can be tolerated if costly large-scale consumer appliance modification is to be avoided, and its production cost is indirectly related to coal (since coke price follows coal price). The authors have previously pointed out[2] that this rise in the coal/coke price ratio favours the use of lower calorific values and increased C.W.G. manufacture; but, again, there is a limit to the proportion of base load C.W.G. if production peaks are to be met economically.

It would appear that oil gas derived from heavy oil by catalytic cracking by the Segas or Onia-Gegi process could find a useful place in meeting peaks, as has been shown by the authors[2]. This is technically feasible since its characteristics are similar to coal gas and a high proportion could be tolerated in the gas mixture, thus enabling C.W.G. to be base loaded. Present conditions of materials cost prohibit the use of oil gas for base load, however, since, although with capital charges it rivals coal gas, Table I shows that complete gasification gas is cheaper in both gross and net cost, if heavy oil is used in both types of plant. The use of butane or propane/air or producer gas mixtures for peak loads of short duration is also economic[2]. It can lead, however, to difficulties regarding gas composition.

The increase of the coal/coke price ratio has resulted in gas made in horizontal retorts being very costly unless diluted with B.W.G. In the area of the North Western Gas Board such plants are, in general, only economic for peak load purposes.

Each rise in the price of coal would have to be accompanied by an increase in the price of coke of double the magnitude if the cost of gas into holder were to remain unchanged. Since this would eventually result in a prohibitive coke price, no relief can be expected in this direction. The continued increase in coal cost must inevitably raise the cost of gas produced in carbonising plant, which remains the chief method of manufacture, producing the whole of our base load gas and comprising a large part of the capital assets of the industry, unless means can be found to increase productivity from such plant.

The use of complete gasification gas of the Tully or Gaz Integrale type is more attractive than C.W.G. for both peak load and base load purposes and can be used in greater proportion with coal gas. The gross cost is, however, greater than the present net cost of continuous vertical coal gas. When heavy oil is used for enrichment the net cost is likely to be less and certainly not greater than the net cost of continuous vertical coal gas. Even with gas oil it is of similar magnitude to the net cost of coal gas. This means that new production plant should take

(1) J. Burns and L. J. Clark: I.G.E. Comm. No. 417, 1952.
(2) T. Nicklin and M. Redman: 'The Economics of Gas Production' I.G.E. (Manchester and District Section) December 14th, 1951.

TABLE 1

Approximate Costs of different methods of Producing Gas at Current Prices of Materials and Plant (Pence per therm) in Plants of Output nominal 4 mill. cu. ft./day (C.V. = 450 B.Th.U.'s/cu. ft.) operating under base load conditions (330 max. days per annum) on new sites.

	Coal Gas in C.V.R.	C.W.G. from gas oil	C.W.G. from heavy oil	Complete Gasific'tn with gas oil	Complete Gasific'tn with heavy oil	Oil Gas (Catalytic) from gas oil	Oil Gas (Catalytic) from heavy oil	B.W.G. (C.V. = 290)	Complete Gasifctn. Gas (C.V. = 330)
(1) Coal	10.97	—	—	3.91	3.91	—	—	—	5.78
(2) Coke	—	3.25	3.25	—	—	—	—	5.40	—
(3) Shift and general labour	0.73	0.21	0.21	0.21	0.21	0.21	0.21	0.33	0.29
(4) Repairs and maintenance	0.93	0.11	0.11	0.11	0.11	0.11	0.11	0.17	0.15
(5) Gas Oil	—	4.08	—	3.06	—	9.07	—	—	—
(6) Heavy Oil	—	—	3.60	—	2.70	—	7.74	—	—
(7) Steam				SELF SUPPORTING					
(8) Water	0.04	0.08	0.08	0.08	0.08	0.08	0.08	0.12	0.11
(9) Electricity	0.11	0.11	0.11	0.11	0.11	0.22	0.22	0.17	0.15
(10) Purification (Materials and Labour)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.17	0.15
(11) Management	0.06	0.10	0.10	0.10	0.10	0.10	0.10	0.16	0.14
(12) Insurance, rents, rates, etc.	0.07								
(13) Materials, etc., Costs	13.02	8.05	7.57	7.69	7.33	9.90	8.57	6.52	6.77
Credit—									
(14) Coke	4.20	—	—	—	—	—	—	—	—
(15) Breeze	0.29	—	—	—	—	—	—	—	—
(16) Crude Tar	1.29	0.36	0.29	0.56	0.45	0.67	0.60	—	0.42
(17) Ammonia	0.11	—	—	0.02	0.02	—	—	—	0.02
(18) By-products receipts	5.89	0.36	0.29	0.58	0.47	0.67	0.60	—	0.44
(19) Net Cost into Holder (pce p.thm)	7.13	7.69	7.28	7.11	6.86	8.23	7.97	6.52	6.33
(20) Capital Charges	2.90	1.50	1.65	1.70	1.85	1.50	1.65	1.40	1.70
Total (gross) Cost into Holder (pence per therm)	10.03	9.19	8.93	8.81	8.71	9.73	9.62	7.92	8.03

Coal .. 82/- per ton. Breeze .. 30/- per ton. Coke to water gas .. 78/- per ton.
Coke .. 75/- per ton. Tar .. 120/- per ton. Gas Oil .. .. 12½d/gallon.
Heavy Oil .. .. 8½d. per gallon.

the form of complete gasification plant (since it is more than competitive with coal gas made in new plant) but cannot replace coal gas made in existing continuous vertical plant unless the net cost of such gas were to rise to the gross cost of C.G. gas.

The introduction of complete gasification for major gas supply would then involve the industry in considerable capital cost and delay (due to plant construction) and it already bears a heavy burden of capital charges which will not be paid off for at least some 10 to 15 years. Moreover, since the bulk of the winter heat load of the nation can only be met most economically by solid fuel, and since this solid fuel should be smokeless, the wisdom of reduction in coke production is doubtful, particularly in view of the large amount of carbonising plant available. In these circumstances, coke, as a prepared fuel, should command a higher price, which would reduce the cost of coal gas production.

To summarise, it is clear that increases in the cost of coal to the industry must continue to raise the cost of gas manufacture (although this may be retarded by the increasing use of C.W.G.), until a point is reached at which it is heavily retarded or even stabilised by the large-scale introduction of complete gasification gas (whether Tully, Gaz Integrale, Lurgi, etc.) and oil gas. By the time this stage is reached considerable difficulty will have been found in supplying gas to base load consumers at a competitive price.

In seeking an answer to this problem, there are many economies which may be achieved, such as increasing the thermal efficiency of stations, the thermal output of existing plant, and the therms per unit of labour employed. Large economies can often be achieved by integration, as has been shown by Hodkinson, and Hodkinson and Taylor[*]. There is clearly a need, however, to prevent cost of production rising further than at present, and, indeed, to reduce it. It was necessary to find a means of materially increasing the productivity of existing assets, thereby avoiding, as far as possible, additional capital expenditure on new plant and sites. In addition, this would reduce existing plant overheads, including labour, maintenance, and capital per therm, and open up a wider field for integration.

Theoretical Considerations

In the area of the North Western Gas Board some 70% of the carbonising plant consists of continuous vertical retorts and it was clear that this type of plant should be examined first with a view to increasing productivity. This was also dictated by a further reason—namely that such plant, if called upon to process slack coals, loses output to such an extent that economies derived from using the cheaper slack are lost. Such smalls may be processed in static carbonising systems, but the coke is less suitable for domestic purposes, fuel consumption per therm is often greater, and dirt and dust nuisance can arise. Additionally these processes require better coking coal (which is becoming scarcer) while continuous vertical plant will produce coke, albeit weak, even from poor coking coal where static processes fail. If, therefore, productivity could be raised in continuous vertical plant, slack coals of poorer quality might be carbonised.

The operation of a continuous vertical retort installation at a calorific value of 500 B.Th.U. per cu.ft. with external B.W.G. dilution to 450 B.Th.U. per cu.ft. results in lower capital charges per therm of gas than if gas were produced directly in the carbonising plant at the lower calorific value. Dependent on the relative coal and coke prices the differences in the net cost of the gases may offset this. In the area of the North Western Gas Board this has recently not been the case and this method of operation by external dilution has been practised in increasing amount, particularly where increased output is required, since the capital cost of new water gas plant is so much less than that of new carbonising plant.

There is, in addition, a slight increase in thermal output from continuous vertical retorts operating at high calorific value. It is clearly advantageous, therefore, to make the coal gas therms at as high a calorific value as

(*) W. Hodkinson: 'Gas Production and Distribution in the North West'—Paper to North Western Gas Board Area Autumn Conference, October 23, 1953.
W. Hodkinson and H. B. Taylor: 'The Development of a Gas Grid', Trans.I.G.E., 1945-6.

possible provided that neither thermal output nor flexibility in choice of calorific value are lost. Furthermore, the economic efficiency of B.W.G. production is higher in an external plant than in the retort where the latter is called upon to produce more B.W.G. than the residual heat in the coke will allow. The conclusion may be drawn that it is better to utilise the heat input through the retort walls to effect carbonisation rather than water gas production, and it was logical to deduce, therefore, that even greater quantities of coal could be carbonised by utilising the whole of the sensible heat in the coke for this purpose rather than for the endothermic production of B.W.G.

It was considered that this could be achieved by injecting a gas into the base of the retort and that the effects would be as follows:—

(1) The coke would be cooled countercurrently to the normal discharge temperature and the heated gas passing up the retort would carbonise increased quantities of coal.

(2) Heat transfer in the charge would be considerably improved. Granular materials with gas-filled interstices are bad transmitters of heat where the operative mechanism is conduction. Indeed, they are generally looked upon, and used, as insulators. Since carbonisation takes place largely by heat conduction from the retort walls the heat transfer process must be considered far from ideal. The best method of heat transfer to granular beds is by convection from hot gases. It has long been appreciated that the rising gases in a vertical retort assist coal preheating and carbonisation. With an injected gas, conditions for even and more rapid heating would improve further and more nearly approach the ideal mechanism.

(3) The increased gas velocity would give greater turbulence, thus reducing normal film thickness and promoting increased heat transfer coefficients.

(4) The additional gas would pick up heat not only from the coke but also from the retort walls, thereby increasing the rate of heat input and speeding-up carbonisation.

(5) Absence of steaming would increase refractory life.

(6) A reduction in the degradation of hydrocarbons could be expected due to reduced partial pressure and reduced time contact in the cracking zone. This might be offset to an unknown degree by degradation caused by direct heat from the carrier gas.

(7) There would be a reduced make of ammoniacal liquor per therm of gas and the oxygen absorption might be expected to be less, thereby reducing the problem of effluent disposal, which is retarding the industry's facility to concentrate production on selected sites.

The Processing of Slack Coals

Calculations were made along the lines of this theory and indicated promise of substantial increase in throughput of coal.

If it were found to be possible to increase retort throughput in this manner, it was felt that it might be possible to process slack coals, at the same time opening up the possibility of processing blended coals in this type of plant, thereby increasing the industry's flexibility in regard to raw material.

Perusal of the literature revealed that the theory was not new. In 1917 Frederick Perkin and John West were granted a patent[4] which proposed the injection of a gas into the base of a continuous vertical retort to 'expedite the heating up of the coal charge' and claiming thereby an increase in the production of lower-boiling aromatic hydrocarbons, a less yield of aliphatic hydrocarbons, increased coal throughput, and an increased tar yield of lower specific gravity. The distillation products were stated to suffer less decomposition due to more rapid passage through the hot zone of the retort. The claims of product yields do not seem to be mutually compatible when compared with unsteamed or steamed vertical results.*

In 1930, Smith[5], in work at Bolton, substituted water gas for steam in vertical retorts, submitting that, since the efficiency of steam decomposition in retorts was only of the order of 25% but in an external water gas plant was 60% and since the latter plant was cheaper in capital costs than carbonising plant, it would be an economic proposition to generate the water gas externally and pass it into the base of vertical retorts. He found that he could substantially increase coal throughput above the figures normally recognised as maxima but considered the high cost of water gas production a disadvantage, although he indicated that the process would lead to a reduction in labour and capital costs per therm. He was limited in his work in that the use of B.W.G. as the carrier gas limited the quantity that could be injected if the calorific value of the final mixed gas were to be maintained above a minimum.

In 1942 Pexton[6] suggested, among four methods of recovering the sensible heat from coke in continuous vertical retorts, (a) the admission of B.W.G., externally generated, to the base of the retort, and (b) the recirculation of coal gas from the top to the base of the retort.

In the light of this knowledge, it is surprising that the process of gas injection has not been developed further.

The Partington Experiments

The next step was obviously practical implementation of the theory, and it was decided early in 1951 to inject producer gas into a bed of retorts at the Partington station in Manchester.

Producer gas was selected because it was readily available, cold, and reasonably clean from the producer battery used for heating the horizontal retorts and for dilution purposes. It was felt that there was little to choose between B.W.G., coal gas or producer gas since the specific heats are similar. Obviously, the quantity of producer gas which could be injected would be small in large-scale operation if the calorific value were to be maintained at the declared figure, but for the purposes of this work the effect of injection of the estimated requirements would have negligible effect on the output of the whole station, although the calorific value from the bed would be low.

The retorts comprised No. 8 bed of the Glover-West installation, consisting of eight 40-in. bell-bottomed siliceous retorts which had been reset in 1948. The whole bench was due for complete rebuild early in 1953. The brickwork was in poor condition and No. 8 bed was the worst in the house. In places, the retort monoliths were less than 1-in. thick and leakage was heavy. The gas offtakes were of the sprayed type with the collecting main at platform level, this main entering the common foul main of the house. No attempt was made to measure the volume of the gas produced, since the experiment was intended solely to assess the process qualitatively. The setting was fired by natural draught producers—one per bed.

The dust and tar content of the producer gas averaged 0.4 grains per 100 cu.ft. and this gas was fed by a 6-in. main through a meter of 4,000 cu.ft. per hour capacity (later supplanted by a Connersville meter of 20,000 cu.ft. per hour capacity. The coal weighed into the bunker which was levelled daily, was the normal mixture for the whole house and consisted approximately of:

Dodsworth	washed doubles	.. ..	36%
Williamthorpe	washed doubles	.. ..	7%
Haydock	washed doubles	.. ..	13%
Gibfield	washed doubles	.. ..	26%
Houghton	washed doubles	.. ..	18%

in varying proportions during the tests. No special arrangements were made, throughout the experiments, to take off the increased volumes of gas; and since three other beds were served by the same governor, this later led to a little difficulty in pressure control.

The 6-in. feeder main branched into two 4-in. pipes running down either side of the bed above the extractor operating bars and, from these, 2-in. vertical pipes were led into the side of the bottom castings just below the worm. It was subsequently found necessary to install a fan to give the requisite supply of producer gas under pressure. The arrangement is shown in Fig. 1.

Due to a variety of reasons, continuous work on a

* The 'steaming' of vertical retorts was just being commenced about this time (1917).

(4) B.P.S., 114937.
(5) W. P. Smith: 'Experiments on the substitution of water gas for steam in the quenching of coke in vertical retorts and its effect upon the products of carbonisation'. I.G.E. Diploma Thesis, 1930.
(6) S. Pexton: Reply to the discussion on 'The Fuel Requirements of Carbonising Plant'—Paper to London and Southern District Junior Gas Associatoin October 16, 1942.

regular shift programme was not commenced until July, 1952, but it was then carried through until the shut-down of the bench in January, 1953. Very interesting results were obtained.

Producer gas was first turned on to the bed at the rate of 5,000 cu.ft. per hour. The coal throughput was not altered but the steam admission was gradually reduced from 20 notches at 14 lb. per sq. in. (on the West-Taylor valves) to six notches. Further reduction caused hot discharges—*i.e.*, the producer gas was insufficient—as calculations corroborated. There was a considerable temperature increase in the third combustion chamber, which could be due either to leakage or what appeared to be a general tendency for the hot zone to move upwards. Dust and tar in the producer gas choked the meter and pipes but this was aggravated by breeze which had found it way back

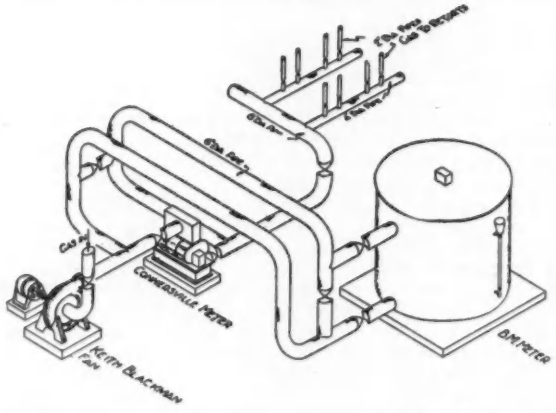

Fig. 1.—Arrangements for injecting gas in the Partington experiments.

into the pipes from the casting. It was also noted that the pressure varied considerably in the bottom ironwork and at times became so high on particular retorts that no gas could be injected with the pressure available (2 in. W.G.); and indeed, when the charge hung—and it showed the tendency to do so often—gas passed backwards into the other retorts, which therefore had more than their share. It was clear at an early stage that regulation of the gas flow to each retort would be a most important problem.

Increased Coal Throughput

Additional producer gas washing equipment and the fan (pressure lift 8 in. W.G.) were then installed, together with more points for pressure measurement. Difficulties in maintaining the continuity of producer gas supply continued, however. A further run with average producer gas rates up to 8,000 cu.ft. per hour showed that bottom pressure varied widely even when the retorts seemed to be working normally. The average pressure was approximately 1 in. W.G. but an isolated pressure of 11 in. W.G. occurred. Temperatures again increased. Frequently the gas was shut off when the pressure rose, and the charge was generally found to be travelling unevenly. The question was whether the uneven travel was due to gas injection or the lack of continuity thereof, or to the poor retort condition.

Further increase in producer gas was made up to 14,000 cu.ft. per hour with four notches of steam at 12 lb. per sq. in. The coal throughput could be increased to 4.6 tons per day compared with the normal 4.1. By this time one retort had collapsed. There was still some blockage of pipes with dust which caused frequent shut-downs, and this certainly mitigated against good coal travel conditions.

The gas rate was then increased to 19,000 cu.ft. per hour for seven retorts and the steam to two notches at 14 lb. per sq. in. Approximately 4.7 tons per retort per day was achieved and the coke had 0.7% volatile matter content with a C.A.B. of 0.053. At this juncture gas was shut off half the bed while injection at the same rate continued on the rest. Within 1½ hours the former showed dirty discharges while the latter remained burnt off. Two hours after turning on the gas again, the dirty discharges cleaned up. This was reproduced several times. Rodding conditions were now improved but not easy. It should be recorded that adjacent beds were also not easy and there was little difference. Trouble still occurred with blocked injection pipes and another retort wall collapsed. At this stage it was necessary to speed up the extractor drive by 25%.

With a gas rate of 20,000 cu.ft. per hour on five retorts, the charges became hot on top and this disappeared on increasing the extraction rate. This condition became frequent and became to be regarded as a useful indication of correct coal throughput. When gas was put on a retort without increase in throughput the charge became hot on top until throughput was increased. If gas was shut off, then dirty discharges occurred until throughput was reduced. The coke began to show signs of blockiness and sometimes hung over the extractor. This again indicated hanging as a price cause, and this was doubtless aggravated by uneven temperatures, since temperature control on all beds was now very difficult due to leakage of coal gas. It will be appreciated that in all these tests it was difficult to measure the rate of coal throughput under steady conditions, because of uneven working. At this rate of 4,000 cu.ft. per hour per retort, the figure averaged, however, approximately 4.9 tons per day per retort, while, with steady working, the coke showed 1.5% volatile matter and a C.A.B. of 0.053.

Promising Preliminary Results

A further run with the same gas rate showed heavy and blocky coke as in the last run but no continuous steaming was practised. The throughput averaged 5.7 tons per retort per day with the C.A.B. and volatile matter in the coke as in the last run. The discharging schedule had to be increased. The extractor was again working at its maximum rate and was therefore 25% faster than in the fourth run. Steam was only used for a two-minute purge after shutting off the gas before discharging. There were no explosions.

The results could be considered far from satisfactory but definitely showed promise and the following conclusions could be made:—

(1) The bottom ironwork and discharges can be kept cool without the use of steam.

(2) It is essential to preserve continuity of injected gas supply, and to this end the source of gas supply and the design of the control gear must be carefully considered. Failure of continuous gas supply to any retort seriously interferes with the working of the retort.

(3) No conclusion could be drawn that erratic coal travel was due to gas injection in view of the condition of the retorts and uneven travel on adjacent beds.

(4) Hanging of coke over the extractor worm, while possibly affected by gas injection, was more likely the result of erratic travel with retort conditions as the prime cause.

(5) Technical supervision in the daytime only was inadequate.

(6) The later stages in particular gave a distinct indication that considerable increase in coal throughput was possible with continuous gas supply. This was confirmed by red tops if coal throughput was not increased, and black discharges when the gas was shut off.

(7) No quantitative estimate could be made of coal throughput possible if no stoppages had occurred. The overall figures indicated, however, that under even conditions the true rate would be well over 50% above normal.

(8) The reactivity of the coke was certainly not impaired and showed signs of slight but not significant improvement over normal.

(9) The explosion hazard during discharging operations was small.

(10) Due to the tendency for large breeze to find its way back down the injection pipes great care in the choice of the position of entry into the casting is necessary.

(11) No conclusion could be drawn as to effect on heats

or fuel consumption of the bed due to coal gas leakage in the retorts.

(12) No conclusion could be reached on the effect on the retort refractories, since monolith failures were imminent before the work began.

(13) Useful experience in operating technique had been gained and the prospects were sufficiently interesting to warrant an exhaustive investigation over an extended period with redesigned equipment, continuous supervision, and facilities for quantitative measurement of all products and conditions.

The Rochdale Trials

It was decided to conduct the detailed investigation at the Rochdale station where there was a Woodall-Duckham setting which was due for a complete rebuild in 1954 and where convenient arrangements could easily be made for measurement of materials and independent laboratory control so that operation of the station was not affected.

(a) Description of Plant

The retort bench consisted of 30 upwardly-heated square-cornered W-D retorts with a major axis dimension of 76 in. The retort faces were last renewed in 1950 with the exception of bottom firebrick. The full retort dimensions are shown in Fig. 2. It is desirable to record these because of their bearing on travel of the charge. Two retorts, Nos. 18 and 20, were selected on one side of the bench to serve for the tests, so that work would not be delayed while scurfing and repairs were in progress. Neither was an end retort, where temperature control on the outside flue usually presents some difficulty. The aim was to work the test retort under operating conditions as near as possible to standard practice. Each retort was arranged with a supplementary gas offtake (at the centre platform end) which passed behind the auxiliary coal hopper into one of two M.S. liquor separation boxes into which the normal offtakes were also connected. The gas offtake from this box was so arranged with valves that the gas made could pass into the existing collecting main or to the test plant via a Bryan Donkin retort house governor. The normal offtakes had to be shortened to do this and consequently could not be provided with liquor sprays, but the additional offtakes were sprayed. The tar and liquor from the separating boxes (which were provided with 'fishing' seals for pitch removal) could be passed either into the retort house tar and liquor system or into an independent system. This consisted of a separating tank with a pumping section from which a duplicated pump supplied liquor to all the necessary sprays, a tar measurement and sampling tank, and a liquor measurement and sampling tank. From here the liquor could be run into the station system. The gas after leaving the governor passed to a vertical tube single-pass water cooled condenser, an electrically driven Connersville exhauster with by-pass governor, a Livesey washer, a Connersville meter (with temperature and pressure measurement), an inlet pressure governor, and thence into the retort house foul main. All condensates flowed into the separate tar and liquor system which also supplied liquor to the Livesey washer.

Each retort had independent coal bunkers which were supplied by the normal coal handling plant from a separate outside hopper reserved exclusively for the test coal. Coke discharges were drawn into a separate skip and could be weighed on Avery scales before sampling and grading tests were performed.

A 1-in. service from the inlet of the inlet pressure governor was taken to the laboratory (at rodding stage level), passing through duplicate oxide purifiers (changed daily), a service governor, and a control valve back into the retort house foul main. The control valve was set so that the lag in the sample line did not exceed 5 min. and the line was arranged to be free of drains and seals. This line was equipped with various sampling points for gas analysis, calorific value, etc.

Arrangements were made for injecting three gases. Producer gas was obtained from the setting CO bus flue and was passed through a vertical water sprayed pipe, a seal and packed sprayed column, a fan (in duplicate), and a Connersville meter with 6-in. connections, after which the pipe branched into two 4-in. pipes which led to the retort bottom ironwork. The pipe was flanged to the inspection door on the back side of the extractor box major axis—*i.e.*, on the opposite side to the curved plate which bears most of the weight of the charge. The point of entry was thus approximately level with the bottom of the C.I. hangers, and it was anticipated that this would give the least danger of coke or breeze blocking the pipe. A 1-in. test service (with similar ancillary equipment to the coal gas service) was taken from the meter inlet to the laboratory and thence to the retort house foul main. At the inlet to the meter (and before the test service) a governed supply of gas from the inlet of the station purifiers was connected, and a connection was also made to the inlet of the test plant meter so that gas could be recycled from retort top to bottom. Twin valves were used with venting in between so as to avoid contamination of the selected gas should any valves leak slightly.

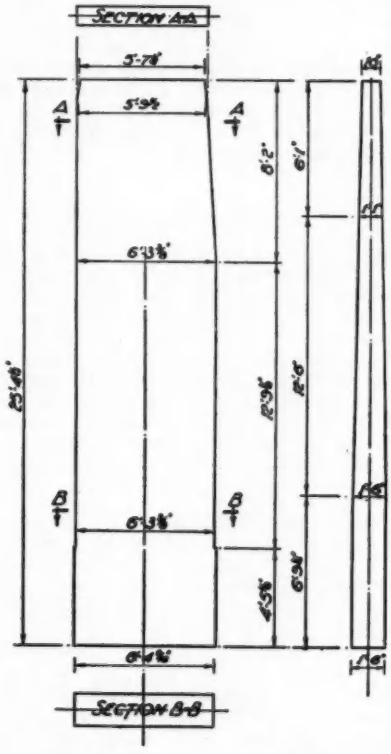

Fig. 2.—Dimensions of the retorts used in the Rochdale trials.

Pressure recorders were installed on both meters, inlet to inlet pressure governor, retort house governors, bottom castings, and in the laboratory.

A separate steam supply (from the 120 lb. per sq. in works mains) with its own reducing valve and shunt meter was provided. This supplied steam to the retorts when steaming of the charge was being carried out and to the two purge steam lines, these being tapped off upstream of the reducing valve but after the meter, and being controlled by two West-Taylor valves which were worked with a fixed setting. On-off control valves were also provided.

The discharge door handwheels were fitted with sliding clamps which were kept padlocked with the doors in the closed position to ensure they were not inadvertently opened causing explosion hazard and possibility of unweighed discharges. The normal W-D extractor gear was used in the earlier tests but was later replaced by special gear which will be referred to later.

The condition of the silica work of the retorts was closely investigated and, apart from a few minor leaks

(mostly at the sliding joint) which were made good by welding and airborne sealing, was good. The shape was reasonably true and there was little flaking or spalling. The top and bottom fireclay was in rather poor condition. The floor joist deflection was excessive and the ironwork condition poor, particularly in respect of joint leakage between the plates of the bottom castings.

(*b*) *Data Collected*

The collection of the necessary data from the tests was carried out in accordance with the recommendations of the British Standard Test Code for Continuous Vertical Retorts (B.S.S. 1034), supplemented as necessary. A few special points deserve mention.

Gas samples were collected continuously at constant rate, precautions being taken against alteration in composition during storage. These samples were at first analysed each shift, but in later tests each day. The apparatus used in the earlier runs was the soap film type described by Gooderham[7], but this was later supplanted by a constant volume apparatus as modified by Gooderham[8].

Calorific values on the ammonia-free and hydrogen sulphide-free gas were recorded continuously on Sigma calorimeters regularly checked against a Boys calorimeter. All coke discharges were weighed immediately after discharge and moisture samples taken. Tar and liquor samples were carefully collected. The water content of the tar was added to the liquor make to give the figures recorded.

The Question of Coke Quality

The make of coal gas was obtained by difference between the total product gas and the injected gas as metered (after correcting for NH_3 and H_2S) and the therms of coal gas by difference between these volumes after multiplication by their average calorific value. The coal gas figures therefore include any change in composition of the injected gas, such as possible degradation or thermal loss due to gas combustion where oxygen is present in the latter. The yields are therefore true net yields of coal gas if no leakages occur. Similarly, the gas analyses of the coal gas were derived from the volumes and gas analyses of the injected gas and the total gas produced.

Considerable importance was attached to measurement of any change in the properties of the coke produced, since, for example, a deterioration in combustibility or an increase in breeze formation might constitute serious obstacles to the process. Shatter index and bulk density were determined, together with careful grading tests on a large portion of the discharges. The reactivity was determined by the critical air blast test[9]. In the fire test the particular thermopile used was not calibrated in B.Th.U per sq. ft. per hour, and the time taken to reach a definite galvanometer reading was taken instead of the specified output of 5,000 B.Th.U. per hour. The fire tests are therefore comparable with each other but not with other standard tests.

It was to be expected that the injection of a gas might modify the hydrocarbon cracking conditions in the retort as compared with standard continuous vertical practice. Some indication of the extent of this would be given by the gas analyses, the volumetric yield of gaseous hydrocarbons and hydrogen per ton of coal of standard inert content, and by the quantity and nature of the tar produced. To assess the change in tar composition the specific gravity and 'free' carbon (*i.e.*, toluene-insoluble material) were determined, together with changes in the properties of a 'standard creosote' fraction obtained by distilling the crude tar in a standard apparatus and collecting the distillate between 200°C. at a constant rate. Reduced cracking might be expected to yield a reduced naphthalene content and carbon hydrogen ratio and an increased yield of phenols and aliphatic hydro-carbons, while aromatic hydrocarbons would be reduced. Some indication of paraffin content could be provided by the aniline point, but a more accurate test would be the determination of the paraffin plus naphthene content by chromatographic separation, since the proportion of aliphatic hydrocarbons at any point in the distillation range of a tar is approximately the same, and since naphthenes, unless they have been considerably dehydrogenated, are predominantly aliphatic in character. The method used was due to McNeil and Vaughan[10], a silica gel column being employed and the chromatogram being developed with petroleum ether. The solvent was used in 10 ml. increments and was evaporated from the eluates which were then weighed. Eluting was continued until no residue was obtained on evaporation, and the sum of the weights of the residues expressed as a proportion of the weighed quantity of creosote taken was designated as paraffins and naphthenes, since aromatic and olefinic compounds are more strongly absorbed and require diethyl ether to be desorbed from the silica gel.

The ammoniacal liquor produced was examined for monohydric phenol and polyhydric phenol content, since changed cracking conditions might also affect its composition. The oxygen absorption was determined to assess the effect on the effluent problem.

(*c*) *Technical Control*

The plant was staffed by one operator per shift with one chemist during the daytime. All plant adjustments were carried out by these operators, including retort temperatures. The operator was present at all coke discharges.

(*d*) *Account of the Test Runs and Operating Observations*

(i) *Procedure.*—The investigations were carried out on a particular coal throughout in order that the results should be strictly comparable between the various tests. The coal chosen was Wath Main washed doubles. The first two tests were carried out with steaming of the charge to make gas of a calorific value of 450 and 500 B.Th.U. per cu.ft. respectively to serve as datum line tests so that the subsequent results with gas injection could be compared with conventional practice. In each case the coal throughput was set at a figure which was considered to be the rated throughput for those conditions, and this was confirmed by guarantee test figures. The throughputs were approximately 6.4 and 8.1 tons per retort per day.

These, and subsequent, tests were conducted over a period of five days preceded by a period of not less than three days when all conditions and variables were kept constant. In the case of the gas injection tests, the gas was applied to the retort at a fixed rate and the coal throughput was then increased very gradually until the volatile matter content of the coke rose above 2.0%, whereupon throughput was decreased until the figure fell just below 2.0%. At this point conditions were stabilised over not less than three days and the test conducted. This procedure of adjusting throughput occupied a considerable amount of time—often over a fortnight—since 24 hours were always allowed before taking samples for volatile matter determinations after an adjustment had been made. Furthermore, it was important to keep other operating variables constant during this time.

(ii) *Throughput of coal achieved.*—The coal throughputs achieved are shown in Table 2, whence it will be seen that 9.5, 12.3, and 14.3 tons per day per retort were attained at gas injection rates of approximately 2,500, 5,000, and 7,500 cu.ft. per hour respectively. Subsequently the injection rate of producer gas was increased to 12,000 cu.ft. per hour when a coal throughput of 17½-18 tons per day was achieved with a volatile matter content well below 2%. It was not possible to conduct a test run under these conditions as the plant had to be shut down in preparation for demolition. There have, as yet, been no indications that a limit has been reached and it may be concluded that carbonisation can be considerably accelerated by gas injection.

(iii) *Cooling of coke.*—At no time during the tests was any overheating of bottom ironwork observed except when gas leakage at ironwork joints occurred (see later). It may

(7) W. J. Gooderham: J.S.C.I., 1938, 57, 388.
(8) W. J. Gooderham: *Analytica Chimica Acta* 2 (1948), 452-464.
(9) 'Report on Coke Quality': Gas Council, Coke Department, July, 1951.
(10) D. McNeil and G. A. Vaughan: Coal Tar Research Association—Private communication.

TABLE 2. DATA RELATING TO COAL AND CARBONISING

Run Number	1	2	3	4	5	6	7
Approx. Rate of Gas Injection cu. ft. / hr.	Nil	Nil	2500 P.G.	5000 P.G.	5000 StationGas	5000 Recycled	7500 P.G
Nature of Injected Gas	—	—					
Coal Carbonised							
tons as charged	31.7	40.5	47.6	60.5	61.5	64.5	71.5
tons corrected to 8% inerts	32.1	40.4	48.1	59.5	59.6	66.5	70 8
Coal throughput/24 hours (as charged)	6.34	8.17	9.52	12.1	12.3	12.9	14.3
Increase in coal throughput/24 hours (Run 1 = 1.0)	—	1.29	1.50	1.91	1.94	2.03	2.25
Coal Analysis—							
Moisture %	3.2	3.0	2.8	5.2	6.1	6.3	4.3
Ash %	3.6	5.2	4.1	4.4	4.6	4.5	4.6
Volatile Matter %	36.8	35.7	35.1	35.8	35.7	35.0	33.3
Fixed Carbon %	56.4	56.1	58.0	54.6	53.6	54.2	57.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Moisture and Ash %	6.8	8.2	6.9	9.6	10.7	10.8	8.9
B.S. Swelling Number	4½	4	—	—	4½	—	5
Sulphur %	1.6	1.8	2.2	1.8	1.7	—	1.7
Bulk Density lbs./cu. ft.	47.7	45.3	47.6	46.3	48.1	47.5	47.5
Calorific Value B.Th.U's/lb. (gross) as received	—	13,300	13,900	13,300	13,100	—	13,650
Injected gas/ton of coal carbonised (as charged) (cu. ft.)	—	—	7,550	9,700	10,000	9,400	13,050
Retort Temperature °C.							
Bottom (centre side)	1360 1360	1365 1370	1330 1340	1360 1365	1360 1370	1370 1350	1360 1350
Bottom (offtake side)	1340 1360	1370 1370	1350 1340	1370 1360	1350 1360	1350 1350	1360 1370
Top	1060 1010	1070 1070	1020 1030	1070 1080	1070 1060	1050 1060	1030 1080
Steam to retort (% to coal as charged)	16.9	10.8	1.5	1.5	2.1	0.9	1.4
Operational Schedule—							
Retort charging	Hourly	Hourly	½-hourly	½-hourly	½-hourly	½-hourly	½-hourly
Extractor wheel speed (mins. per rev.)	52	39	—	25.6	24	24	18
Retort discharging	1½ hrs.	Hourly	Hourly	Hourly	Hourly	Hourly	45 mins.
Augering of offtake(s)	once/shift	once/shift	once/shift	once/shift	once/shift	once/shift	once/shift
Rodding	Hourly	Hourly	Hourly	Hourly	Hourly	Hourly	Hourly

NOTE.—Run 6, coal carbonised corrected to 8% inerts should read 62.5.

be concluded that the coke can be adequately cooled and ironwork overheating prevented by the use of injected gas, without having to reduce bottom temperatures in the combustion chambers.

(iv) *Purging and Discharging.*—It was found possible to dispense with the use of steam immediately after turning on the gas and the only steam used in Runs 3-7 was for purging purposes. Purging before discharging was carried out as at Partington by turning on the steam to the bottom castings, then shutting-off the gas and waiting 2 min. for any gas pockets to clear. (The point of entry of the purging steam was in the centre of the long side of the taper coke hopper just above the discharge door casting.) On one or two occasions an explosion occurred when the door was opened, and this was eventually traced to diffusion of dead gas from the injection pipe into the casting. It was overcome by introducing a second steam purge into the gas line immediately downstream of the valve used to shut off the gas supply. After this no explosions occurred.

It was necessary to have enough steam to form an effective blanket in the taper casting and three notches at 120 lb. per sq. in. were used on each West-Taylor valve. When the steam was turned on there was a sharp rise in bottom pressure in the retort (to some 3 in. W.G.) until the gas was turned off. This was due to sluggishness in response of the retort house governor. Similarly if the gas was turned on too quickly after discharging it took some 15 sec. for the pressure to fall to normal if the steam was left on. Immediately the steam was shut-off, a slight vacuum occurred until the governor closed sufficiently. The duration of this was, however, slight. If the gas was shut-off (before discharging) before steam was put on, a vacuum developed in the bottom ironwork, and this was deemed to be bad practice since air infiltration at casting leakages might conceivably cause explosion. The effect of these purges was clearly shown on the retort house governor pressure recorder. Obviously in a bench of retorts operated in this way the effect on the governor would be small so that the fluctuations in pressure in a retort being discharged would not be compensated for. The sluggish response of the governor used here, therefore, probably simulated the effect that would be experienced on a large bench. It is desirable to cater for these pressure variations in plant design, particularly with regard to ironwork joints and the joint between seating casting and brickwork but since it is not unusual for retort charges to hang and blow the discharge door seal (at 4 in. W.G. approximately) such variations are doubtless already taken care of by plant contractors.

(v) *Time taken to increase coal throughput.*—Coal throughput was at first increased, after turning on injected gas, when the charge became red on top, but it was soon found that increases could be made 4 hours afterwards. More recent tests have indicated that throughput can be substantially increased almost immediately after injecting gas or, alternatively, after increasing the rate of injection. This affords a rapid way of increasing output.

(vi) *Bottom chamber pressure.*—The pressure in the bottom castings, apart from during discharging operations, was of the order of ¼-½ in. W.G. or less when gas was injected at the rate of 2,500 cu.ft. per hour, rising to ¼-1 in. W.G. at 5,000 cu.ft. per hour and ½-2 in. W.G. at 7,500 cu.ft. per hour. The slight pressure in the botom casting may be regarded as an advantage should the door or ironwork leak or the water seal be lost. Fig. 3 shows part of the chart of the bottom chamber pressure in Run 7. On one occasion when the water seal on the discharge door blew, the charge was found to be hanging, and on rodding the pressure immediately fell, so that this represents little change from conventional conditions.

Some difficulty arose with leaking joints between the plates of the bottom ironwork when using coal gas injection. This leaking gas frequently lit up and overheated the ironwork. Much less trouble with lighting-up was experienced with producer gas. It could be immediately extinguished by shutting-off the gas and turning on steam, but relit on reversion to injection. Examination of the joints revealed that they were wide, made with unsuitable jointing compound, and that the plates fitted together badly. It should be recalled, however, that the ironwork was old and in need of complete renewal. The main trouble arose at the centre end of the casting which butted up against the casting of the opposite retort, consequently giving no access for pointing. It is considered that this leakage trouble could be overcome by the use of an alternative

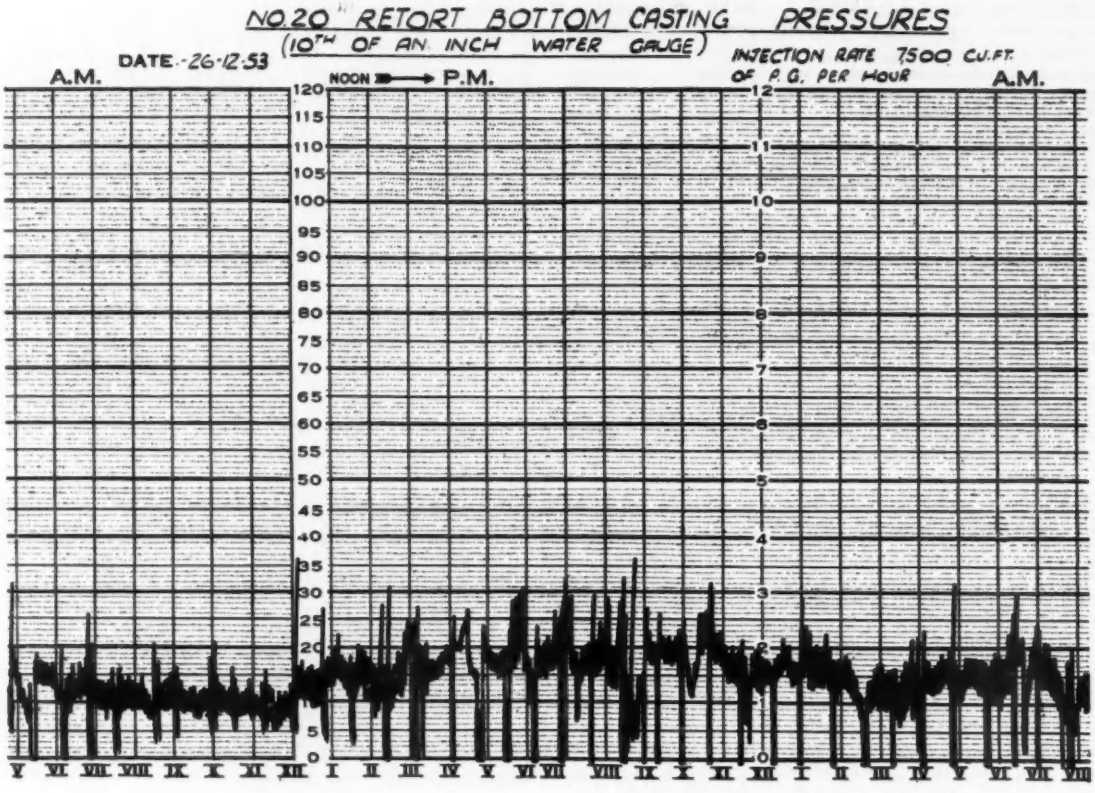

Fig. 3. Part of the record of pressure in the coke chamber during Run 7.

jointing medium, thinner joints, and standard jig-machined plates accurately assembled. In common with other plant operating under gas pressure, the bottom ironwork should be tested under, say, 8 in. W.G. air pressure before and after assembly, being designed to take blanking-off plates. It would also be important to ensure a tight brickwork/ironwork joint. Appreciable success was achieved by internal caulking of joints after the retorts had been scurfed. Such leakage can cause appreciable thermal loss, particularly when the injected gas is of high calorific value like coal gas.

(vii) *Effect on Retort Brickwork.*—At one time was any leakage of gas visible in the combustion chambers and temperature control was always satisfactory. There were usually a few leaks at the bottom sliding joint when a retort had been scurfed, but these were easily patched and were not abnormal. Retorts were always airborne sealed after scurfing. The effect of some nine months working with gas injection on the retort brickwork was not noticeable and the retort condition appeared to be as good at the end of the trials as at the beginning.

(viii) *Injection pipes.*—No trouble whatsoever occurred with blockages in the injection pipes, and the position chosen could be considered satisfactory.

(ix) *Extraction.*—Up to and including Run 3 the normal extraction gear was used, but it became clear when increasing the throughput for Run 4 that extraction could not be made fast enough with this equipment unless the main drive were speeded up, which was not desirable because of its effect on the remainder of the house. Accordingly modified gear was designed. The existing friction driven wheel was substituted by a sprocket wheel with a Renold drive from a geared motor of speed 3 r.p.m. This motor was actuated by a time switch on a 5-min. cycle. The extractor wheel could be run from 15 sec. to 5 min. in the cycle and the Renold reduction was 6:1 so that the extractor was driven at ½ r.p.m. while the contactor was closed. This arrangement gave no trouble. There was at no time any tendency for the coke to hang over the extractor as at Partington, nor was any blocky coke produced.

(x) *Rodding and Coal Travel.*—The test retort was rodded by the top man who rodded the remaining retorts in the house. No attempt was made to single it out for special attention in this respect but it was, of course, rodded by the technical staff from time to time to obtain the 'feel' of the charge and assess any new effects. The retort was rodded hourly and inspected not longer than every half-hour by the technical staff. Only in Run 7 was it found necessary to do extra rodding on the half-hour and then on only three occasions. Rods less than 7 ft. 6 in. or 8 ft. in length were found to be unsatisfactory.

Coal travel was found to be good and rodding easy. On Runs 4-7 rodding was, indeed, easier than normal; and this may have been due to the modified extraction gear, since it is well known that less frequent and longer cuts give more positive extraction and better travel. It was impossible to get a rod longer than 8 ft. down the centre platform rodding hole due to the clearance of the coal bunkers, which is testimony to the good travel, since any hanging low down at this end could not have been cleared.

It was to be expected, and was in fact confirmed, that interruptions in travel of the charge were more serious than normal in view of the higher speed of travel, since any cavities increase at a greater rate than in conventional practice and are therefore more difficult to remedy unless detected quickly. Careful rodding is therefore essential; but, after all, it is essential in conventional vertical retort practice.

(xi) *Coal Charging.*—It became necessary to charge the auxiliary coal hopper every half-hour from Run 4. A bigger hopper or automatic charging is desirable.

(xii) *Scurf.*—Scurf formation seemed little different to normal although there was a slight tendency to an increased thickness in the lower reaches of the retort and at the top. The scurfing cycle showed no sign of requiring modification since, on Run 6 with recycled gas, where scurf deposition could be expected to be greatest, the retort ran 31 days without any trouble and took only approximately 50 hours to scurf.

(xiii) *Starting up after scurfing.*—No change from con-

ventional practice was attempted, the retort being started up with steaming until it was on its own coke, when gas could be injected immediately.

(xiv) *Coke appearance.*—In Run 6 a change in the appearance of the coke was noticed compared with earlier runs. The pore structure was more uniform and slightly more open, and a large part of the discharge was of a shiny black appearance rather than grey, but there were few traces of soot.

(xv) *Gas offtakes.*—The additional gas offtake was not found to be necessary since governing conditions could be adjusted to cope with the increased gas velocity, and its use was discontinued.

(xvi) *Fuel consumption.*—This could not be measured, but an increased flow of producer gas was required. This was estimated (from damper positions) not to exceed 25%.

(e) The Quantitative Results

These are shown in Tables 2, 3, 4, 4A, 5, 6, 7, and 8. The figures show that the desired increase in coal throughput was achieved and that carbonisation was considerably accelerated—some 2¼ times the throughput under normal operating conditions to produce gas of calorific value 450 B.Th.U. per cu.ft. being achieved in Run 7, or some 75% more than the throughput at 500 C.V. No increase in combustion chamber temperatures above those used in conventional practice was necessary to obtain these results.

The coal used was a moderately swelling one and its composition as shown by proximate analysis remained reasonably constant throughout the runs, although the high volatile matter content in Run 1 and the low figure in Run 7 are difficult to understand.

The injected gas per ton of coal carbonised will be seen to increase as coal throughput is increased. This is probably due to increased slip up the sides and ends of the charge.

In the case of runs with producer gas injection it will, of course, be realised that the gas produced is at too low a level of calorific value to be used for distribution to consumers under present conditions of declared calorific value, but this would not apply if B.W.G. were used as the 'carrier' gas, or a mixture of B.W.G. and re-cycled gas. The derived figures for the coal gas yields and calorific value are, however, important as there would appear to be no reason why similar results could not be reproduced with any other 'inert' gas such as B.W.G. ('Inert' in this sense is used to define a gas which would not be expected to deteriorate or change appreciably in composition in passage through the hot retort charge.) They also give indication of any changes which occur when coal gas is injected if the yields and calorific values are compared under similar conditions of injection rates after correction for injection leakage. It should be mentioned at this point that the enrichment content of producer gas and, of course, coal gas has been allowed for in calculating the hydrocarbon enrichment value (H.E.V.). The gaseous yields are best compared on the basis of constant inert matter content in the coal, and the actual plant results of Table 3 are calculated to 8% inerts (the approximate average during the tests) in Table 4.

Point of Interest No. 1.

Study of this Table reveals many interesting points. In the first place it will be observed that the calorific value of the coal gas was high and increased as the injection rate increased. It will be appreciated, however, that the calculation of this calorific value would be affected by any leakage which was occurring from the bottom ironwork, since the volume of producer gas subtracted from the total volume of gas produced would be too high. This would have the effect of pushing-up the calculated calorific value. It is desirable, therefore, to make an estimate of this leakage and allow for it in the calculations. An estimate may be made by a nitrogen balance, using the nitrogen content actually measured in Run 6 (since this cannot be affected by leakage) as the nitrogen content of the true raw coal gas produced in Runs 3, 4, and 7. These estimated leakages are set down in Table 3 in terms of cu.ft. per hour, and the figures given seem reasonable having regard to the pressures attained in the bottom ironwork and the leakage tests made at the time. It will be noted that injected gas leakage was some 10% of the volume supplied, in Run 7. This correction downgrades the results of Run 7

TABLE 3 YIELDS OF PRODUCTS

Run Number	1	2	3	4	5	6	7
Total Gas Produced—							
Therms	2775	3051	3541	4627	6301	3686	5669
Volume (cu. ft.)	600,490	594,000	855,900	1,238,300	1,204,230	614,090	1,630,040
Calorific value (B.Th.U's/cu. ft. gross)	462	513.6	412	373.4	522.9	600.2	347.5
Injected gas used							
Therms	—	—	345	677	2719	3581	1097
Volume (cu. ft.)	—	—	307,400	590,250	608,500	596,180	933,820
Calorific value (B.Th.U's/cu. ft. gross)	—	—	112.1	114.7	446.8	600.2	117 4
Coal gas made (by difference)—							
Therms	2775	3051	3196	3950	3582	3686	4572
Volume (cu. ft.)	600,490	594,000	548,500	648,050	595,730	614,090	696,220
Calorific value (B.Th.U's/cu. ft. gross)	462	513.6	583	610	601	600.2	657
Coal gas volume purified with 4% air admission (cu. ft.)	621,640	614,800	567,740	670,750	616,590	635,590	720,620
Coal gas per ton of coal as charged, purified, with 4 % air admission—							
Therms	87.6	75 3	67.2	65.3	58.3	57.2	64.0
Volume (cu. ft.)	19,600	15,150	11,940	11,090	10.030	9,850	10,080
Calorific value (B.Th.U's/cu. ft. gross)	447	497	563	589	581	581	635
H.E.V.	33.0	32.7	33.2	33.8	29.6	28.9	33.1
Tar (dry)—							
Galls./ton coal as charged	15 4	14.8	18.1	16.6	16.4	15.7	16.2
Water content %	5.2	4 9	4.4	11.3	14.1	16.6	8.4
Liquor—							
Galls./ton coal as charged	18 5	18.5	16.8	19.1	19.2	20.7	19.5
Coke discharged—							
tons (dry)	20.8	28.4	33.7	41.6	42.2	42.5	47.85
cwts. (dry) per ton coal as charged	13.12	14.03	14.16	13.75	13.72	13.20	13.38
cwts. (dry) per ton dry coal	13.56	14.46	14.57	14.50	14.61	14.09	13.99
Calculated injected gas leakage in bottom ironwork—							
Volume (cu. ft.)	—	—	13,000	14,000	not computed	not computed	92,000
Hourly rate (cu. ft./hr.)	—	—	108	117	—	—	767

TABLE 4 YIELDS OF PRODUCTS CORRECTED TO 8 % INERTS IN COAL

Run Number	1	2	3	4	5	6	7
Total Gas Produced—							
Therms	2738	3057	3501	4708	6495	3800	5730
Volume (cu. ft.)	592,500	595,200	846,200	1,261,000	1,242,000	633,100	1,647,000
Calorific value (B.Th.U's/cu. ft. gross)	462	513.6	412	373.4	522.9	600.2	347.5
Injected Gas Used—							
Therms	—	—	341	689	2803	3692	1109
Volume (cu. ft.)	—	—	304,200	601,000	627,000	615,000	944,000
Calorific value (B.Th.U's/cu. ft. gross)	—	—	112.1	114.7	446.8	600.2	117.4
Coal Gas Made (by difference)							
Therms	2738	3057	3160	4019	3692	3800	4621
Volume (cu. ft.)	592,500	595,200	542,000	660,000	615,000	633,100	703,000
Calorific value (B.Th.U's/cu. ft. gross)	462	513.6	583	610	601	600.2	657
Coal gas/ton coal (8 % inerts) purified with 4 % air admission—							
Therms	86.5	75.5	66.5	66.4	60.1	59.0	64.7
Volume (cu. ft.)	19,350	15,180	11,800	11,260	10,340	10,160	10,180
Calorific value (B.Th.U's/cu. ft. gross)	447	497	563	589	581	581	635
H.E.V.	32.6	32.7	32.8	34.4	30.5	29.8	33.4
Tar (dry)—							
Galls./ton coal (8 % inerts)	15.2	14.8	17.9	16.9	16.9	16.2	16.4

(and, for that matter, of Runs 3 and 4) but it is felt that the revised figures are not far from the facts and are not optimistic. The results corrected for leakage in the producer gas tests are given in Table 4A, while the calculated gas analyses for coal gas are given in heavy type in Table 5. Examination of Table 5 reveals that the nitrogen content calculated for the coal gas without correction was lower than when correction for leakage is made, as would be expected from the loss of nitrogen from the system with producer gas which contains 55%-60% thereof.

The calorific values of the coal gas produced now appear to be reasonably steady with increased gas injection (apart from the lower figure for Run 3) and are confirmed, for injection at the rate of 5,000 cu.ft. per hour, by the values for Runs 5 and 6. Moreover, the thermal yields per ton of coal are very constant, as would be expected if the volatile matter content of the coke was reasonably constant (as Table 6 shows) and if there were no marked change in cracking conditions.

The fact that the calorific value in Runs 4 and 7 is higher than in Run 3 might be explained by reduced cracking conditions, but the tar yield appears to reduce, which is a reverse indication.

Consideration of the analyses of the creosote fraction of the tar shows that there is no significant difference in composition in Runs 3, 4, and 7 to indicate either increase or decrease in cracking, nor for that matter in Runs 5 and 6. The free carbon content does, however, decrease somewhat in Run 7; and while this might indicate reduced cracking, it is hardly significant.

Point of Interest No. 2.

The second point of interest is a definite indication that H.E.V. is higher in the producer gas injection tests than in the steaming runs and the tar yield is definitely higher throughout. Higher tar yields are usually indicative of reduced cracking conditions and it is usually considered that the increased tar yield in continuous vertical retort carbonisation, as compared with that of horizontal retort

TABLE 4A YIELDS OF PRODUCTS CORRECTED TO 8 % INERTS IN COAL WITH RUNS 3, 4 AND 7 CORRECTED FOR BOTTOM LEAKAGE

Run Number	1	2	3	4	5	6	7
Total Gas Produced—							
Therms	2738	3057	3501	4708	6495	3800	5730
Volume (cu. ft.)	592,500	595,200	846,200	1,261,000	1,242,000	633,100	1,647,000
Calorific value (B.Th.U's/cu. ft. gross)	462	513.6	412	373.4	522 9	600.2	347.5
Injected gas used (corrected for leakage)—							
Therms	—	—	327	672	2803	3692	999
Volume (cu. ft.)	—	—	291,400	586,400	627,000	615,000	850,500
Calorific value (B.Th.U's/cu. ft. gross)	—	—	112.1	114.7	446 8	600.2	117.4
Coal gas made (by difference)——							
Therms	2738	3057	3174	4036	3692	3800	4731
Volume (cu. ft.)	592,500	595,200	554,800	674,600	615,000	633,100	796,500
Calorific value (B.Th.U's/cu. ft. gross)	462	513.6	572	599	601	600 2	594
Coal gas per ton coal (8 % inerts) purified with 4 % air admission—							
Therms	86.5	75.5	66.8	66.7	60.1	59.0	66.3
Volume (cu. ft.)	19,350	15,180	12,080	11,500	10,340	10,160	11,530
Calorific value (B.Th.U's/cu. ft. gross)	447	497	553	580	581	581	575
H.E.V.	32.6	32.7	32.8	34.4	30.5	29.8	33.4
Tar (dry) —							
Galls./ton coal (8 % inerts)	15.2	14.8	17.9	16.9	16.9	16.2	16.4
Thermal yield per ton coal (8 % inerts) if coal gas were diluted to 450 B.Th.U's/cu. ft. with B.W.G. of 285 B.Th.U's/cu. ft.	86.5	87.7	88.3	92.7	83.5	82 0	91.2
Cu. ft. per ton of 8 % inert coal (after allowing for leakage of injected gas) of:—							
C_nH_m	332	280	300	590	—	320	390
H_2	9960	8100	5550	6160	—	5100	6000
CH_4	2750	2830	3140	2060	—	2290	2440
C_2H_6	440	380	280	530	—	410	420
$CH_4+C_2H_6$	3190	3210	3420	2590	—	2700	2860

TABLE 5 GAS ANALYSES

Run Number		1	2	3		4		5	6	7	
Total Gas Produced	CO_2 %	4.4	3.4	4.9		4.7		2.7	1.8	4.0	
	O_2	0.5	0.3	0.4		0.5		0.5	0.2	0.5	
	C_nH_m	1.8	1.9	1.7		2.8		2.9	3.4	1.7	
	CO	17.5	12.8	15.5		16.9		12.9	7.9	19.0	
	H_2	53.9	54.9	34.4		32.8		50.3	53.6	30.0	
	CH_4	14.9	19.2	18.0	19.6	9.9	12.4	21.0	24.1	10.7	12.5
	C_2H_6	2.4 } 17.3	2.6 } 21.8	1.6		2.5		3.1 } 24.1	4.3 } 28.4	1.8	
	N_2	4.6	4.9	23.5		29.9		6.6	4.7	32.3	
		100.0	100.0	100.0		100.0		100.0	100.0	100.0	
	S.G. (Air=1)	0.45	0.42	0.61		—		—	—	—	
	H_2S(Grns. per 100 cu. ft.)	580	570	360		290		600	560	310	
Injected Gas	CO_2 %			6.0		6.4		3.8		5.7	
	O_2			0.0		0.0		0.9		0.0	
	C_nH_m			0.0		0.1		1.6		0.0	
	CO			26.0		26.3		18.1		27.5	
	H_2			8.3		8.0		50.2	As above	8.3	
	CH_4			0.3	0.3	0.4	0.4	16.2	17.8	0.3	0.3
	C_2H_6			0.0		0.0		1.6		0.0	
	N_2			59.4		58.8		7.6		58.2	
				100.0		100.0		100.0		100.0	
Coal Gas made (calculated)—											
	CO_2 %			4.3	**4.3**	3.2	**3.2**	1.6	1.8	1.7	**2.2**
	O_2			0.6	**0.6**	1.0	**0.9**	0.1	0.2	1.2	**1.0**
	C_nH_m			2.7	**2.6**	5.3	**5.2**	4.2	3.4	4.0	**3.5**
	CO			9.6	**9.9**	8.3	**8.7**	7.6	7.9	7.6	**10.0**
	H_2			49.1	**48.2**	55.3	**54.4**	50.3	53.6	59.2	**53.2**
	CH_4			27.9	**27.3**	18.4	**18.2**	26.0	24.1 28.4	24.6	**21.7**
	C_2H_6			2.5	**2.4**	4.8	**4.7**	4.6	4.3	4.2	**3.7**
	N_2			3.3	**4.7**	3.7	**4.7**	5.6	4.7	−2.5	**4.7**
				100.0	**100.0**	100.0	**100.0**	100.0	100.0	100.0	**100.0**

carbonisation, indicates less severe cracking in the former system. This is confirmed by reduced naphthalene production in vertical retorts and several other features. The fact that the tar yield was greater in the injection runs and the H.E.V. was higher might be taken to demonstrate that cracking was more pronounced in the steaming runs. The volumetric yields of 'unsaturateds' (which include benzene) and 'saturateds' per ton of coal given in Table 4A suggest otherwise. If it is accepted that cracking conditions in vertical retorts are less severe than in horizontal retorts, then the explanation of the good tar yield under injected gas conditions is probably a more selective and beneficial cracking mechanism whereby there is less complete degradation to carbon and hydrogen. This hypothesis finds some confirmation in the lower free carbon content of the tar under injected gas conditions. The important thing is, however, that improved H.E.V. has been achieved without loss of tar yield. It is important to remember, too, that different designs of continuous vertical retorts have different cracking characteristics, and figures of H.E.V. higher than those of 32-33 obtained in Runs 1 and 2 are common. Furthermore H.E.V. is a function not only of plant design but of the mechanism of cracking, for there can be little doubt that if the primary tar of destructive distillation were cracked in the presence of a catalyst, the H.E.V. would be considerably increased compared with thermal cracking for a given tar consumption. Alternatively, the same degree of hydrocarbon enrichment could be derived from a smaller quantity of tar by a catalytic cracking process.

The correction of the figures for leakage is justified by consideration of the oxygen contents of the derived gas without leakage correction, since nitrogen deficiency is apparent. It is also justified by a consideration of the volumes of gas produced if the rich coal gas were diluted to 450 B.Th.U. per cu.ft. by B.W.G. at a calorific value of 285 B.Th.U. per cu.ft. In Table 4 the yields would be, for Runs 3, 4 and 7, 89.5, 93.5, and 97.2 therms per ton of coal. Since the yield is, of course, proportional to the H.E.V., and these figures are 32.8, 34.4, and 33.4, there would appear to be an error in Run 7, since, while the H.E.V. is less than Run 4, the gas yield at 450 B.Th.U. per cu.ft. would be more. Table 4A shows that the yields follow the H.E.V. figures.

It was not possible to correct the results of Run 5 for leakage, since the nitrogen figures of both gases are too similar for accurate derivations to be made.

Point of Interest No. 3.

The third point of interest is that the thermal yield and H.E.V. are poor when coal gas injection is used, whether this be at a calorific value of 450 or 600 B.Th.U. per cu.ft. This could be due either to leakage or to degradation of the hydrocarbons in passage through the charge. If leakage of bottom ironwork were the cause, and the occurrence of this has been mentioned earlier, the thermal loss would be some four times that of producer gas leakage in the case of Run 5 and some 5½ times in Run 6. The approximate loss of 7 therms per ton at 600 B.Th.U. per cu.ft. amounts to some 600 cu.ft. per hour, which is not a very high leakage figure considering the low specific gravity of the gas. Moreover, in Run 5, there will be some thermal loss due to combustion, due to the oxygen in the injected gas; and if it be assumed that hydrogen were combusted rather than coke, the loss would be approximately one therm per ton. Comparison of the calculated calorific values with that of Run 4 with producer gas indicates no marked drop which could be attributed to degradation. It would be expected, however, that the injected gas passing up through the hot coke in the lower part of the retort would suffer some degradation. But the tarry vapours evolved further up the retort would be expected to be little different in mode of evolution or velocity of travel upwards in any of the three test runs, and could not, therefore, be expected to show any change in composition. Table 7 shows that they do not, in fact, do so.

It was thought that some indication of degradation or leakage might be given by the volumetric yield per ton of coal of the gaseous hydrocarbons and hydrogen since the gas analyses give little help. (Table 5). If leakage were the cause then yields of both hydrogen and hydrocarbons would be expected to be low while degradation would reduce only the latter and increase the hydrogen. The figures are shown in Table 4A, and in the case of Run 6 there is some indication that there is leakage, as both hydrogen and saturated hydrocarbons are low. The

TABLE 6 DATA RELATING TO COKE

Run Number	1	2	3	4	5	6	7
Cwts./ton dry coal (Dry)	13.56	14.46	14.57	14.50	14.61	14 09	13.99
Average Analysis—							
Moisture%	7.9	11.3	6.5	5.7	4.4	4.8	4.1
Ash %	6.3	6.8	6.1	5.4	6.0	5 4	5.5
Volatile matter %	1.5	1.3	1.9	1 6	2.1	2.2	2.1
Fixed carbon %	84.3	80.6	85.5	87 3	87 5	87 6	88.3
	100.0	100.0	100.0	100.0	100.0	100 0	100 0
Shatter Index—							
Over 2 inch	52.5%	46.0%	48.0%	43.0%	41.0%	49 0%	45 2%
Over 1½ inch	67.0%	67.6%	66.0%	67 0%	68.0%	76.0%	66 3%
Bulk density (lbs./cu. ft.) on air-dried coke	18.5	22.0	21.5	21.5	20.0	18.5	21.0
CAB Number	0.058	0.059	0.057	0.056	0.054	0.055	0.051
Minutes to " half red " in fire test	25	27	24	24	26	23	23
Grading Test (as discharged)—							
Over 2"	27.1%	36.2%	35.2%	33.2%	32.1%	34.3%	34.6%
2"–1"	40.0%	32.4%	38.7%	46.7%	45.6%	44.9%	47 5%
1"–¾"	12.2%	8.4%	7.5%	6.8%	8.4%	7.5%	9.6%
¾"–½"	7.9	9.3	9.2				
½"–¼"	6.0 } 20.7%	6.4 } 23.0%	4.5 } 18.6%	} 13.3%	} 13.9%	} 13.3%	} 8.3%
Under ¼"	6.8	7.3	4.9				
	100.0%	100.0%	100.0%	100.0%	100 0%	100.0%	100.0%

hydrogen yield is certainly not high as it would be if over-cracking was taking place. This is an important problem, since at first glance it might be thought that gas re-cycling was not a proposition. It is therefore felt from this that no definite conclusion can yet be reached on this problem, but it is advisable to recall that carbonising conditions which produce the highest H.E.V. are not necessarily the most economic. The matter turns on the relative prices of coal, coke, tar, and the retort house cost per therm, high coal and low coke prices favouring high H.E.V. (with low coke production), and *vice versa*. Under the conditions ruling in the area of the North Western Gas Board, however, the highest H.E.V. will yield the lowest net cost per therm. The question of leakage is important if B.W.G. is injected, since the thermal loss would be some 2½ times that of producer gas.

The leakage and degradation question also enters into the consideration of the amount of gas injected. It will be noted from Table 3 or 4 that this quantity is less than the make in Run 3, approximately equal to it in Run 4 (when the coal throughput is about doubled) and considerably greater in Run 7. If it is desired to produce gas of constant calorific value and at the declared figure then, when using B.W.G., the quantity for dilution to 450 B.Th.U. per cu.ft. would be more than adequate for gas injection under conditions similar to Run 3 (and the surplus could be added externally), would be rather inadequate under conditions similar to Run 4, and grossly inadequate under conditions similar to Run 7 (which would therefore require a measure of coal gas re-cycling). The proportion of coal gas to B.W.G. would, however, not be large; and even if degradation were found to take place, it could be expected to be small due to the low partial pressure of the hydrocarbons.

The bottom ironwork of the test retorts was in a similar poor condition to that of the rest of the installation, which has received no major ironwork repairs for upwards of 10 years.

It may be concluded, therefore, in relation to coal gas yields, that a yield of at least 60 therms per ton of gas at a calorific value of 575 B.Th.U. per cu.ft. (purified) can be obtained, because this was obtained with bottom ironwork in very poor condition, and that, with good bottom ironwork, 65 therms per ton of gas at the same calorific value is not unreasonable

The yields of coke are fairly consistent and high. There is some evidence that yields decrease with increased injection. This is probably due to reduction of CO_2 in the injected gas. It is interesting to note that the CO_2 figures of the product gas are quite low and actually decrease as injection rate increases. The CO_2 content of the re-cycled gas in Run 6 was remarkably low. It may be concluded that the shatter index shows no significant change as compared with conventional operation, and this remark holds good for bulk density. There is a distinct and important reduction in breeze production which would have a not inconsiderable effect on cost

TABLE 7 DATA RELATING TO TAR

Run Number	1	2	3	4	5	6	7
Gallons/ton coal (8 % inerts)	15.2	14.8	17.9	16.9	16.9	16.2	16.4
Water content of tar produced %	5.2	4.9	4.4	11.3	14.1	16.6	8.4
Specific Gravity of dry tar (60°F)	1.078	1.082	1.073	1.069	1.071	1.077	1.076
Free carbon in dry tar %	3.28	4.48	1.66	1.72	1.38	1.15	0.95
Standard Creosote (200–330°C) analysis							
% yield on dry tar	39.9	36.0	38.2	41.3	36.7	36.9	43.5
S.G. (60°F) on dry tar	0.997	0.990	0.998	1.0079	1.0064	1.0095	1.017
Aniline point °C	1.5	1.2	–0.8	4.0	1.9	8.2	2.1
Phenols %	37.4	34.0	34.8	34.8	32.2	36.8	36.3
" Aliphatic " content by chromatography	10.9	10.9	8.9	10.5	9.8	8.7	8.3
*Carbon % by wt.	82.15	81.91	83.26	82.0	82.5	—	—
*Hydrogen % by wt.	8.71	8.69	8.89	8.58	8.65	—	—
*C/H ratio by wt.	9.43	9.41	9.37	9.56	9.54	—	—
*C/H atomic ratio	0.786	0.786	0.781	0.796	0.795	—	—

* The Authors are indebted to the Coal Tar Research Association for the determination of these figures.

TABLE 8 DATA RELATING TO CRUDE AMMONIACAL LIQUOR

Run Number	1	2	3	4	5	6	7
Yield (galls./ton coal as charged) ..	18.5	11.5	16.8	19.1	19.2	20.7	19.5
Yield from moisture in coal (galls./ton coal as charged)	7.2	6.7	6.3	11.6	13.7	14.1	9.6
Yield from carbonising process (galls./ton coal as charged)	11.3	11.8	10.5	7.5	5.5	6.6	9.9
Analysis—							
Free NH_3 %	0.49	0.57	0.56	0.36	0.53	0.71	0.49
Fixed NH_3 %	0.58	0.75	0.59	0.50	0.57	0.75	0.39
Phenols %	0.36	0.37	0.49	0.38	0.36	0.34	0.35
H.T.A. (Aeration test) p.p. 100,000 ..	224	368	274	135	355	291	321.6
O/A p.p. 100,000	1975	2223	1892	2260	2039	1778	1965

per therm of gas. Moreover, although this reduction does not appear as large coke, it does appear in the domestic size grade which commands the maximum price. There is some evidence that reactivity and ignitability are slightly increased, and it may be concluded with certainty that they remain at least as good as the coke produced by conventional practice.

The high water content of tar in Runs 4, 5, 6, and, to a lesser extent, 7, was probably due to separator trouble. The tar separated quite well on standing.

Examination of the data on ammoniacal liquor reveals no significant change in composition. The O/A remains approximately the same, but the reduced yield is an important contribution to the effluent problem. The similarity in yields between Runs 1, 2, and 3 is surprising. It cannot be accounted for by variations in condenser outlet temperature, since, although this variable was not thermostatically controlled, the variations were small and in the range where change in water vapour content with temperature is small.

Lastly, the thermal output of coal gas from the retort has been increased by almost 70% in Run 7 compared with Run 1. This means that the fuel consumption per therm is appreciably reduced. If it be assumed that the producer gas input increased by 25% in the tests with high injection rates (*e.g.*, Run 7) then fuel consumption per therm would be approximately 70% of that with normal operation and approximately 55% per ton of coal carbonised. If the injected gas were B.W.G. this reduced fuel consumption would be offset to a variable but appreciable degree by the lower thermal efficiency, compared with the carbonisation process, of external B.W.G. plant.

Appraisal of the Trials

The following conclusions may be drawn as a result of the work at Rochdale:—

(1) Appreciable increase in productivity in the form of coal throughput may be achieved in continuous vertical retorts by using accelerated continuous carbonisation.

(2) The results are most encouraging and present a quite different picture to the first results at Partington.

(3) A good coal gas yield of therms per ton with a satisfactory H.E.V. and high calorific value appear to be attainable with the elimination of bottom ironwork leakage. There appears to be no reason why these attributes cannot be fully exploited with blue water gas.

(4) A good tar yield is obtained, at least comparable with conventional practice.

(5) There is reduction in liquor make.

(6) No conclusion may yet be drawn as to the extent of hydrocarbon cracking or as to the maximum yields attainable when coal gas is injected, but there are indications that degradation is small.

(7) A good coke yield, approximately equal to the theoretical, is obtained.

(8) There is appreciable reduction in breeze formation.

(9) Combustibility of coke is at least as good as in conventional continuous vertical carbonising practice.

(10) Fuel consumption per ton of coal is approximately halved per ton of coal carbonised.

(11) Thermal output of the plant is increased by some 70%.

(12) The coke may be cooled to give no overheating of ironwork.

(13) Bottom ironwork leakage would appear to present serious difficulties due to overheating and thermal loss. Careful attention to design, erection, and maintenance is essential.

(14) The purging technique successfully prevents explosions during discharging.

(15) Coal throughput may be quickly increased after gas injection is commenced.

(16) There was no evidence of refractory deterioration.

(17) Coal travel was satisfactory.

(18) Lack of conscientious rodding may lead to serious coal travel problems.

(19) Scurf formation and scurfing cycle were negligibly affected.

(20) No special gas offtake arrangements were necessary.

(21) Further work is required with gas-tight bottom ironwork at still higher injection rates on the pilot plant scale, and on a larger scale to ascertain how the process works under normal station conditions.

Carbonisation of Slacks

Qualitative experiments on the carbonisation of Wath Main washed smalls (0-½ in.) with and without gas injection were also conducted at Rochdale. Without gas injection and steaming down to a calorific value of 450 B.Th.U. per cu.ft., good coal travel and effective carbonisation were possible at throughputs of just under 6 tons coal per day. Gas injection enabled this figure to be raised to 7-8 tons per day. Further experimentation is required to find the optimum injection rates for a particular slack throughput.

In both methods of operation the coke was much denser than when using coal doubles; and in the case of gas injection was very hard, having the appearance of coke oven coke. Very large pieces of coke were also produced —*i.e.*, of 6 in.-8 in. cube and even bigger.

It was evident that, for a given increase in coal throughput, the quantity of injected gas required was considerably more than when using doubles coal. This appeared due to a high slip up the end walls of the retort, for the charge became very red on top only a few minutes after the extractor had cut. This redness consisted of a single bar of colour immediately adjacent to the end walls. It was evident, too, that the charge had shrunk away from the wall. This shrinkage would be expected to be greater on retorts of long major axis.

It would be expected that with small coal the plastic layer occurring when the coal has softened would be more

continuous and less permeable to the passage of gas than when doubles are carbonised, since relative movement of the larger pieces of coal in travel would be expected to disrupt the plastic layer, for this layer is very thin. (When high extraction rates were tried with slack, uncarbonised coal was extracted and certain pieces of coke clearly exhibited the plastic condition with coal attached to one side of a thin transitional zone and a large amount of coke on the other. This condition is confirmed by Weston's observations[11].) The injected gas will therefore be less effective in carbonising if it travels up the outside of the charge, because it either cannot penetrate the softened coal or passes preferentially up cavities caused by shrinkage adjacent to the end walls. In either event the importance of retort shape is obvious and since a circular cross-section would appear to be ideal, retorts of short major axis dimension could be expected to be more suitable. This has been found to be the case and will be referred to later.

It cannot be assumed, however, that slacks cannot be effectively carbonised in large retorts, and the fact that throughputs of slack were attained equal to those of doubles is of considerable importance in that it would enable a reduction in cost into holder to be made where slacks are available cheaper than doubles. Other advantages are enumerated later.

Future Development Work

The Rochdale trials having demonstrated the considerable potentialities of accelerated continuous carbonisation, the North Western Gas Board is undertaking further development work which may be divided into four phases, as follows:—

(*a*) *Extension of the Rochdale tests on coal doubles to higher coal throughputs at Partington.*

It was pointed out earlier that no limit to coal throughput appeared to have been reached at Rochdale. Arrangements are therefore now in hand to continue the investigation at Partington at higher throughputs until some limitation is found. Two 82-in. lambently heated Woodall-Duckham retorts in a new installation will be used, where it is expected that bottom ironwork leakage troubles will not arise. Opportunity to study coal gas re-cycling will, therefore, also be taken. The most likely limitations foreseen are increased bottom pressure and rate of heat transmission through the retort walls. Automatic charging of the auxiliary coal hoppers will also be tried out since this particular installation has considerable headroom between the coal valve and coal bunkers. The installation is also equipped with blending bunkers.

(*b*) *Study of the carbonisation of slack coal.*

The effective carbonisation of slacks by the Rochdale process would open up the possibility of use of blended coals and, with this in mind, the Bollington (Cheshire) station of the North Western Gas Board has been equipped for the process, and investigations commenced early in January, 1954. Coal blending plant has been installed to investigate the carbonisation of blends wherein coal has been crushed to at least 80% below ¼ in. size. This plant comprises bunkers, turntable coal feeders, Carr disintegrator, and a mixer. The retort installation consists of six siliceous Glover-West 40-in. retorts with steaming chambers. Two retorts are being reset in silica with continuous minor axis taper and different major axis tapers.

Work to date has shown that, with coal gas re-cycling, heavy scurf formation occurs in the steaming bell and this will therefore be eliminated in the resetting. Effective carbonisation of slack at a throughput of some 6 tons per retort per day has been achieved when the maximum throughput with steaming only was 3 tons per retort per day. It will be observed that this throughput is almost as great as that achieved in the short trial period at Rochdale on 76-in. retorts.

(*c*) *Large scale operation at Partington.*

The development from the pilot plant stage to full scale operation will be carried out at Partington on a bench of 16 Woodall-Duckham 82-in. lambently heated retorts. This bench is one of two in a new (1952) installation of nominal 4 mill. cu.ft. per day capacity. The response of the process to normal works operating conditions will be carefully appraised, for its success depends largely on trouble-free operation with less technical supervision than was given at Rochdale. If the experiment is successful then the second bench will be converted.

Blue water gas will be injected to the retorts after washing and cleaning but it will not be H_2S free. This gas will be obtained from the two 3½ mill. C.W.G. sets at present used to dilute refinery tail gas, which will be treated with a mixture of producer gas and blue water gas as a temporary expedient. Provision is also being made to re-cycle a quantity of coal gas from the outlet of the ammonia washing plant. The purpose of this is twofold. First, it enables the calorific value of the final gas to be maintained at the declared figure without any external enrichment or dilution other than the B.W.G. injected, and, secondly, it enables coal throughput to be maintained in the event of failure of B.W.G. supply.

The discharging operations will be carried out by specially designed interlocking gear, and the flow rate of gas to each retort will be controlled by independent volumetric governors.

It is essential for safety in operation that the discharging operations should be carried out in a definite sequence and that the equipment should incorporate the necessary interlocks to avoid any operation being carried out other than in sequence. The requirements of such equipment are that the discharging door cannot be opened when the gas is on the retort and that steam purging must be applied so as to ensure that pockets of gas have been displaced before the door is opened. The gas must not be capable of being turned on to the retort when the discharging door is open or not properly closed. The retort must not be left without injected gas for more than a definite period, which is adjustable between 1 and 5 min., and the equipment should include the necessary warnings to indicate failure of steam supply, gas supply, or electricity supply. Furthermore, one must ensure that the steam purge is actually on when it is supposed to be, and the equipment should cater against valve faults, such as sticking closed. Similarly, one must ensure that the gas is on when it is supposed to be, to cater against valves sticking closed. In reverse manner the equipment must take care of leaking gas and steam valves.

The sequence of the discharging operation is as follows:—

The steam valve to the retort opens, followed by the closing of the gas valve, an interlock being so arranged that the gas valve cannot shut until the steam valve is opened. The closing of the gas valve actuates the time control which allows the steam purge to carry on for a period of 1 to 4 min., this period being adjustable on the controller. At the end of this time the lock on the discharge door is released and the coke discharged. On completion of discharge the cycle is repeated in reverse—namely, the steam purge continues for 1 to 4 min. followed by the opening of the gas valve and the closing of the steam purge valve.

The design of the equipment for the sequence operation and interlocking has been developed in collaboration with the Lockheed Company, who are supplying such equipment for the Partington retorts. The control of the gas flow to the individual retorts has been designed in collaboration with the Bryan Donkin Company, Ltd., who are also supplying the necessary equipment for Partington.

It is expected that the modified installation will be at work by June, 1954.

(*d*) *Quenching of the Rochdale retorts*

By the time this paper is presented, six retorts at Rochdale will have been water quenched in order to 'freeze' the charges in an attempt to ascertain the mechanism of carbonisation. Two retorts will be working with gas injection and two or four without at the time of quenching. It is expected that useful information on retort design modification and operating control will be gained, particularly in accelerated carbonisation of slack.

It is hoped to present the results of these further investigations in future papers.

[11] F. R. Weston: 'The Mechanism of Carbonisation in Continuous Vertical Retorts—The Bow Common Experiments', 'GAS JOURNAL', June 11, 1947.

Perspective of the 'Rochdale' Process in Gas Production Economics and Coal Availability

Little purpose can be served by development work of this nature if the outcome can find no place—or can show no *prospect* of finding a place—as an economically-justified undertaking. It is therefore desirable to examine the import of the Rochdale results on the economics of gas production. These will be considered in relation to a unit of 4 mill. cu.ft. per day nominal capacity.

Table 9 shows the estimated cost of production of gas in this unit when working the 'Rochdale' process employing either B.W.G. or complete gasification gas of the

TABLE 9

	Results A		Results B	
	With B.W.G.	With C.G.G.	With B.W.G.	With C.G.G.
	Pence/therm		Pence/therm	
Coal	11.01	11.67	11.89	12.43
Shift and general labour	0.39	0.41	0.42	0.44
Repairs and maintenance	0.68	0.68	0.73	0.74
Water	0.06	0.06	0.06	0.06
Electricity	0.11	0.11	0.11	0.11
Purification (materials and labour)	0.11	0.11	0.12	0.11
Management	0.07	0.06	0.07	0.06
Insurance, rent, rates, etc.	0.03	0.02	0.03	0.03
Materials, etc., costs	12.46	13.12	13.43	13.98
Credit—				
Coke	4.54	5.13	5.01	5.56
Breeze	0.22	0.19	0.24	0.21
Crude Tar	1.29	1.27	1.39	1.36
Ammonia	0.12	0.12	0.13	0.13
By-products receipts	6.17	6.71	6.77	7.26
Net cost into holder	6.29	6.41	6.66	6.72
Capital charges if all plant is new	2.07	1.93	2.21	2.09
Gross cost into holder if all plant is new	8.36	8.34	8.87	8.81
Capital charges if gas injection equipment only is new (i.e. modification to existing plant)	0.53	0.60	0.55	0.65
Gross cost into holder in modified existing plant	6.82	7.01	7.21	7.37

modified Tully or Gaz Intégrale type to produce gas base load at a calorific value of 450 B.Th.U. per cu.ft. with the same material costs used in Table 1.

Figures have been calculated for two sets of results, the first, tabulated as 'Results A,' referring to 65 therms per ton of 575 B.Th.U. per cu.ft. gas which, as has been pointed out before, can reasonably be expected; and 'Results B,' referring to 60 therms of 575 B.Th.U. per cu.ft. gas, which are the poorer results obtained in Test 6 due to leakage and which could be improved if this leakage did not occur. The costs of 'Results B' will therefore represent the minimum improvements which the process could attain, and 'Results A' the average results with normal operation and sound bottom ironwork.

The effect of gas injection is to raise the output of gas to some 8.4 mill. cu.ft. per day with 'Results A' and some 7.7 mill. cu.ft. per day with 'Results B' with B.W.G., and some 9.7 mill. cu.ft. per day with 'Results A,' or 9 mill. cu.ft. per day with 'Results B' with complete gasification gas, when the coal throughput is doubled similar to conditions in Runs 4, 5, and 6 at Rochdale. This implies that the 82-in. retorts will each take some 14 tons of coal per day.

The import of these costs may be more easily assessed by study of Tables 10 and 11.

Reference to Table 10 will show that if it is required to provide a quantity of gas of some 4 mill. cu.ft. per day, the construction of a new plant to meet this load would mean, with conventional continuous vertical retort plant, that the cost would be 10.03d. per therm until such time as the capital charge of 2.90d. per therm is paid off. Such a plant would cost some £1,300,000 to £1,400,000.

Operated on the 'Rochdale' process, this plant would cost some £1,480,000 with 'Results A' and £1,460,000 with 'Results B' and would produce respectively 8.35 or 7.71 mill. cu.ft. per day at a cost of 8.36d. or 8.87d.

If an existing 4 mill. cu.ft. per day installation were converted to the Rochdale process, however, the capital expenditure would be some £380,000, or an additional capital charge of some 0.53 to 0.55d. per therm on the whole of the gas.

Moreover, productivity of labour would be increased and other standing charges reduced such that the net cost of the whole of the gas would be 6.29/6.66d. instead of 7.13d. per therm, which means that the net cost of the extra gas would be 5.52/6.14d. per therm. If the extra gas is considered to bear the whole capital charge due to the £380,000 expenditure, this would amount to 1.02/1.14d. per therm, giving a gross cost of 6.54/7.28d. per therm. This may be compared with a cost of 10.03d. per therm if new plant had had to be built, so that the new load could be met with gas some 3d. per therm cheaper and with the expenditure of some £1,300,000 less. The saving is therefore of considerable magnitude.

TABLE 10

The Effect of Operating the "Rochdale" Process with Blue Water Gas Injection on the Production Costs of a 4 million¹cu. ft. per day Base Load Carbonising Plant.

Basic prices: Coal .. 82/- per ton. Coke .. 75/- per ton Breeze .. 30/- per ton Tar .. 120/- per ton

Cost of Gas into Holder—	Costs—pence per therm					
	Net		Capital		Gross	
(*a*) In a new 4 mill. cu. ft. per day continuous vertical retort plant	7.13		2.90		10.03	
(*b*) In a new 8 mill. cu. ft./day continuous vertical retort plant	6.91		2.60		9.51	
	A	B	A	B	A	B
(*c*) In a new 4 mill. cu. ft./day continuous vertical retort plant with B.W.G. injection raising the output to 8.35/7.71 mill. cu. ft./day	6.29	6 66	2.07	2.21	8.36	8.87
(*d*) In an existing 4 mill. cu. ft. per day continuous vertical retort plant with B.W.G. injection raising the output to 8.35/7.71 mill. cu. ft. per day	6.29	6.66	* 0.53	* 0.55	6.82	7.21
(*e*) The cost of the extra 4.35/3.71 mill. cu. ft. of gas per day in (*d*)	5.52	6.14	* 1.02	* 1.14	6.54	7.28

* These figures do not include capital charges on existing plant since the annual charge is not affected by the way it is operated

TABLE 11

The Effect of operating the "Rochdale" Process with Complete Gasification Gas Injection on the Production Costs of a 4 million cu. ft. per day Base Load Carbonising Plant.

Basic price: Coal .. 82/- per ton Coke .. 75/- per ton Breeze .. 30/- per ton Tar .. 120/- per ton

Cost of Gas into Holder—	Costs—pence per therm					
	Net		Capital		Gross	
(*a*) In a new 4 mill. cu. ft./day continuous vertical retort plant	7.13		2.90		10.03	
(*b*) In a new 8 mill. cu. ft./day continuous vertical retort plant	6.91		2.60		9.51	
	A	B	A	B	A	B
(*c*) In a new 4 mill. cu. ft./day continuous vertical retort plant with complete gasification injection raising the output to 9.69/8.95 mill. cu. ft./day	6.41	6.72	1.93	2.09	8.34	8.81
(*d*) In an existing 4 mill. cu. ft. per day continuous vertical retort plant with complete gasification gas injection raising the output to 9.69/8.95 mill. cu. ft./day	6.41	6.72	* 0.60	* 0.65	7.01	7.37
(*e*) The cost of the extra 5.69/4.95 mill. cu. ft. of gas per day in (*d*)	5.90	6.40	* 1.02	* 1.18	6.92	7.58

* These figures do not include capital charges on existing plant since the annual charge is not affected by the way it is operated.

Furthermore it may be observed that the gross production cost (of 6.54) 'Results A,' of the extra 4.55 mill. cu.ft. per day is less than the net cost if a new plant had been built (7.13) and approximately equal to it with 'Results B.' This may not always be so since it depends on the coal/coke price ratio. A material increase in the coke/coal price ratio could reverse this, but the substantial advantage of reduced capital charges would still remain, so that the cost of gas production with the 'Rochdale' process would still be considerably reduced.

The extra capital expenditure of £380,000 comprises:—

	£
Two 4 mill. B.W.G. sets, small holder, etc. ..	200,000
Re-cycling and B.W.G. mains; automatic injection gear	50,000
Purifiers	100,000
Condensers, exhausters, detarrers, extra ammonia washer, naphthalene washing, etc.	30,000
	£380,000

It is now interesting to observe the effect on costs of using complete gasification gas (instead of B.W.G.) for injection, as set out in Table 11. In this case both the gross and net production costs are higher than those using B.W.G. injection in existing carbonising plant at the commodity prices taken, as is shown by comparison with Table 10. The capital charges on the extra gas are similar, however, since the output of the installation is now raised to 9.69/8.95 mill. cu.ft. per day (yielding 5.69/4.95 mill. cu.ft. per day of extra gas) and the increased cost of complete gasification plants is spread over more gas. It is interesting to observe, however, that if a new plant were built to give this output of 9.69/8.95 mill. cu.ft. per day employing complete gasification gas injection, the capital charges per therm are only 1.93/2.09d. as compared with 2.07/2.21d. per therm with B.W.G. injection so that the gross cost of the total gas is approximately equal at 8.34/8.81d. per therm to that of 8.36/8.87d. per therm with B.W.G. injection, in spite of the fact that the net cost at 6.41/6.72d. per therm is higher than that of 6.29/6.66d. per therm with B.W.G. injection. This is because the increased cost of complete gasification plants above B.W.G. plants on a total capital expenditure of some £1,400,000 to £1,500,000 is negligible and is spread over a much larger quantity of gas (*viz.*, 9.69/8.95 mill. cu.ft. per day as against 8.35/7.71 mill. cu.ft. per day with B.W.G.).

These facts are important in deciding the type of plant to make the injection gas. Over a wide range of prices and for any given price the cost of carburetted complete gasification gas is always cheaper than that of C.W.G. whether gas oil or heavy oil is used for carburetting. Put another way, this means that the cost of the oil enrichment therm would have to fall considerably to be comparable with the coal enrichment therm. In the case of uncarburetted gas the difference in cost per therm is not large but the complete gasification gas is slightly cheaper. When it is considered that the capital costs of the two plants are not widely different, that a complete gasification plant could be operated with coke instead of coal, and that, if carburetting at any time might be required, it is then clearly seen that injection gas should preferably be provided by complete gasification sets. This has the outstanding advantage that it would enable the gas industry to control the coke market and to make the most economic gas dictated by the relative costs of coal, coke, and oil at any partciular time both now and in the future. This will allow of a very flexible system of gas manufacture, and at any time the industry could, if complete gasification of coal were being operated, increase its coke production if either the price of coke increased or if the demand for a smokeless fuel rose, due to a national fuel policy, smoke abatement, or other reason.

With this in mind the North Western Gas Board has, for some time, been carrying out development work on modifications to the Tully system of complete gasification at Kendal in order to improve the gaseous thermal yield of the process. This work will be reported in a later paper by other members of the Board's staff.

The method of calorific value control on any installation operating with the 'Rochdale' process would be by variation in the relative proportions of the injected B.W.G. (or complete gasification gas) and re-cycled gas. On an installation operating solely on re-cycled gas, the re-cycled gas could be drawn off at the outlet detarrer which could be placed on the suction side of the exhauster. The injected gas would be pumped by a separate machine since the pressure lift required is low compared with that required to pump the final gas through the remaining purification train. This arrangement would give the minimum power consumption.

Utilising complete gasification plants for producing injection gas, the question arises whether they should be of the carburetted or non-carburetted type and it may well be that the most economic arrangement would be to provide central oil enrichment plants in unit sizes of some 6 mill. cu.ft. per day and capable of producing calorific values ranging from 450 to, say, 800 B.Th.U. per cu.ft.

At this point it is desirable to summarise the economics of production of some 4 mill. cu.ft. of gas per day in the different types of plant, and Table 12 shows the cost of the extra gas by gas injection with B.W.G. and complete gasification gas, together with the costs abstracted from Table 1.

TABLE 12

Costs of producing approximately 4 million cu. feet of gas per day.

Process	Costs, pence per therm		
	Net	Capital	Gross
"Rochdale" process, B.W.G. injection, Results A ..	5.52	1.02	6.54
"Rochdale" process, B.W.G. injection, Results B ..	6.14	1.14	7.28
"Rochdale" process, C.G.G. injection, Results A ..	5.90	1.02	6.92
"Rochdale" process, C.G.G. injection, Results B ..	6.40	1.18	7.58
New installation of continuous vertical retorts	7.13	2.90	10.03
C.W.G. using gas oil	7.69	1.50	9.19
C.W.G. using heavy oil	7.28	1.65	8·93
Complete gasification gas using gas oil	7.11	1.70	8.81
Complete gasification gas using heavy oil ..	6.86	1.85	8.71
Catalytic oil gas using gas oil	8.23	1.50	9.73
Catalytic oil gas using heavy oil	7.97	1.65	9.62

Consideration of this Table shows that the 'Rochdale' process, even with the modest Results B, provides by far the cheapest gas for any new load. With Results A, or even Results B, it can produce cheaper gas than the present production cost of many small stations, owing to the greater productivity of labour and the reduction of other overhead charges. The process could therefore enable production stations which are not now uneconomic to be closed down more quickly as well as stations which are already uneconomic.

Other advantages now become apparent. The process enables a rapid increase in gas output to be achieved without the use of costly oil enrichment, but, since the gas is cheap, the obvious rôle would be to use the process base load.

It is also clear that the nominal output of an installation could be obtained by the use of much lower retort temperatures than are at present considered necessary and this would lead not only to a longer life of refractory materials but possibly also to the production of a much more reactive smokeless fuel.

Finally, the process appears to offer distinct prospect of allowing continuous vertical retort plant to carbonise slack coals without loss of coal throughput and even at higher throughputs than those which can now be employed. It therefore follows that slack and coals of small size, which the National Coal Board has indicated will represent an increasing proportion of its output, could be effectively treated in existing plant at no greater cost.

The important feature of this is that the process will facilitate the blending of coals of medium caking quality with the weakly-caking coals which form the major potential output of the National Coal Board.

Conclusions

In conclusion it may be said that the process offers distinct promise of realising the original requirements and that it can lead to:—

(*a*) An appreciable reduction in the production cost of gas produced in continuous vertical retorts.

(*b*) A material saving in capital expenditure for additional production capacity.

(*c*) The possibility of accelerating production in economic-sized units at a minimum capital expenditure within the limits of physical integration.

(*d*) Considerably increased flexibility of the vertical retort both with regard to output and yield of coke.

It further indicates the possibility of:—

(*a*) Blending of coal with a view to reducing costs and making use of lower grade coals.

(*b*) The production of a more suitable domestic smokeless fuel.

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They also acknowledge the co-operation given by Mr. J. Wilson and Mr. C. H. Bamber (General Managers, Manchester and Oldham-Rochdale Groups of the Board) and the Station Engineers at Partington and Rochdale, which enabled the work described to be carried out.

Finally, they wish to record their appreciation of the work of Mr. H. Crompton, the team of technical assistants who staffed the Rochdale plant, and colleagues of the Production Department, Technical and Planning Division of the Board, who have so willingly helped in the preparation of the paper.

DISCUSSION

The Chairman, **Mr. A. K. Collinge** (Preston), said he felt the Manchester and District Section of the Institution was honoured in providing a platform for the presentation and discussion of a paper of such importance to the industry as a whole. It was a notable contribution to the economics of gas production which would attract very considerable attention, and the discussion now to follow would be but the commencement of discussion throughout the production side of the industry, for every case where the 'Rochdale' process was considered for adoption would present different sets of circumstances requiring individual attention.

To increase by a considerable proportion the productive capacity of existing plant was a very praiseworthy achievement, and none the less praiseworthy because the underlying principles had been known, as the authors pointed out, for many years. The internal heating of coal had been practised for a long period in various types of complete gasification plants. Many years ago the Fuel Research Board showed that the heat taken up by the coal during carbonisation in a vertical retort was about 11 therms per ton. During research into the heat balance at Lostock Hall works, Preston, in 1944, it was estimated that with 10% steaming, 3.3 therms per ton were transferred to the coal in the upper part of the retort by the ascending gases, which perhaps explained in some degree why the 'Rochdale' system worked. Variation in results obtained might be due to the difference in the exothermic reactions of different coals, which amounted to 2.24 therms per ton or 20% of the heat required for carbonisation. The paper made it evident that in order to obtain an increase in throughput beyond about 20% when producing 450 B.Th.U. gas and using blue water gas for injection it was necessary to re-cycle a proportion of coal gas. The authors' suggestion of injecting complete gasification gas would reduce the proportion of coal gas required, which would be an advantage, and no doubt the development work being carried out on the Tully plant was directed to increasing the calorific value as well as the thermal yield per ton.

One of the major advantages offered by the process from the operational angle was the enormous increase in the flexibility of the vertical retort, which in itself would have far-reaching effects difficult to assess in actual value. The process should bring about a marked reduction in the high cost of peak load gas, and would certainly have a bearing on gasholder storage capacity. A further important advantage was the possibility of using low-grade coals, a problem to which Mr. D. P. Welman, Chairman of the North Western Gas Board, had directed their attention at the autumn meeting last year.

Controlled Cracking of Tar Vapour

The authors concluded by stating that the process offered distinct promise, and that it indicated the possibility of further developments of considerable importance to the industry. Valuable work had been carried out for which great credit was due, and they would await with interest the results of the four phases of development work which were being carried out. If he might suggest a further field for development it would be an investigation into the controlled cracking of tar vapour by operating with a space above the top of the charge. That, also, was a very old story, having first been stressed by Professor Vivian B. Lewes in 1904. In 1934 an increase of no less than 17 therms per ton was obtained in Birmingham by that means, but there was a serious reduction in throughput owing to reduced carbonising time. About the same time he (Mr. Collinge) was able to operate a whole retort house at Preston on controlled cracking conditions and obtained very promising results, but the serious loss in throughput more than counterbalanced the advantages gained. It was a possibility that such reduction could be more than recovered by the 'Rochdale' process.

Mr. **W. Hodkinson,** O.B.E., Chief Technical and Planning Officer, North Western Gas Board, said that since early 1937 a major part of his working life had been spent on the development of projects designed to facilitate either physical and/or administrative integration within the gas industry, and he took pride in the fact that the pattern set in the early days by the team with whom he had the privilege to work was now widely—indeed generally—accepted by the industry under its post-1949 structure. Both types of integration and combinations thereof had played a material part in alleviating the effect on gas price of the continually rising cost of raw materials and labour, but they had now reached the position where increasing capital charges for new plant placed grave restrictions on the development of many desirable schemes for the physical integration of production capacity, and, unfortunately, for the development of balanced load characteristics based on a reasonable proportion of base load demand from the industrial field.

In planning the integration of the North Western production capacity during 1949-50 that problem was quite apparent, and much of the integration effected to date had been achieved on the basis of production capacity made available by improved efficiency and output from units of plant in existence prior to nationalisation. They could foresee the time when that capacity would be absorbed, and this, coupled with the need for major plant replacement and renewals, caused the Board to seek new methods of increasing productivity from its existing assets.

What the 'Rochdale' Process Might Mean

The authors indicated that there was reason to believe they had solved this major problem, and it was perhaps interesting to speculate on the effect that this solution might have on gas production matters in the North West. At present some 70% of the coal gas made in the area was produced in continuous vertical retorts, a capacity of no less than 190 mill. cu.ft. per day. After paying due regard to the limitations of site capacity in certain instances and other restrictions associated with certain plants, it could be stated that plant at present producing some 132 mill. cu.ft. of gas per day and carbonising 6,600 tons of coal could, when converted to the 'Rochdale' process, produce 263 mill. cu.ft. and carbonise efficiently 13,200 tons of coal per day. The flexibility of approach to planning which this potential afforded to the Board was tremendous, and only served to indicate the importance of the Partington conversion which they believed would set the seal on three years of patient and exhaustive development work.

It would now appear that complete gasification in standard low-pressure units such as Tully and Gaz Integrale would offer the most suitable injection gas, and this opened up a field for (a) the use by the industry of low caking coals, and (b) a wide degree of flexibility in the production of coke. They had already established the flexibility of the 'Rochdale' process and, incidentally, this was demonstrated effectively by one of their enterprising technicians engaged on a pilot plant who switched the two retorts from nominal throughput to double throughput in the time it took him to alter the extractor and turn on the gas valve.

His interest in this process started with the desire to make increased volumes of gas from existing plant on existing sites in order to achieve substantial economies and speed-up

the process of physical integration, and it had now extended to an interest in the possibility of carbonising low grade coals to produce satisfactory cokes and to achieve flexibility in the type of coke produced in continuous vertical retorts. Indications to date were promising and he hoped that before the end of the year they would be able to report on their work in that direction.

The clamour for smokeless zones and for a smokeless fuel to facilitate the development of smokeless zones became more insistent, and the gas industry could not afford to sit back and wait for the Coal Board to find means of satisfying that demand. At the last autumn research meeting Sir Charles Ellis spoke at some length on that subject and indicated the lines on which they were working when he referred to the effect of time-temperature in the early stages of the carbonising processes. It was just possible that—inadvertently—the 'Rochdale' process of accelerated throughput fitted into the pattern which he indicated.

Origin of the Process

Mr. **T. Campbell Finlayson,** Chairman of the Woodall-Duckham Construction Co., Ltd., said that when one read that day in such reliable publications as *The Times* and the *Manchester Guardian* what might be termed the *fait accompli* of the 'Rochdale' process and what it would do for the gas industry one was rather diffident to enter the lists at all. Development work came under two main headings—the pioneering of something entirely new or the re-examination of something which had been tried before and which failed for some cause or other. Each type of work was equally valuable and just as meritorious. He was convinced that many a good idea lay buried in the mass of published technical literature and old patent specifications. As the authors pointed out, the idea of introducing a gas into the base of continuous vertical retorts undoubtedly originated many years ago in the West organisation.

The authors of the present paper had taken up that old idea, the significance of which was probably never appreciated at the time when it was first patented, and they had analysed and experimented with it in the light of present-day equipment and present-day needs. They were to be congratulated on the enthusiasm and the comprehensiveness with which they had undertaken the investigation, which might have a considerable influence on the method of operating continuous vertical retorts in the years to come.

He congratulated the North Western Gas Board on its generosity and courage in making available the results of its pilot scale work at such an early date. It would have been so easy to keep the work to itself until it had established the 'Rochdale' process on a commercial scale. Seeing that every area board had some type of continuous vertical retort in operation the early publication of this work gave them the opportunity of thinking out the possible application of the process under their own special conditions. Speaking as a plant designer and therefore as one who was very interested in the outcome of this development, he expressed to Mr. Welman, Chairman of the North Western Board, his thanks for the opportunity his Board had generously afforded Woodall-Duckham's technical staff in collaborating with the Board's staff in the extensive commercial-scale tests of the 'Rochdale' process on the new Woodall-Duckham installation at Partington, which were to take place in the immediate future and which were referred to by the authors in their paper.

Gas-making from Wider Range of Coals

What interested him most about the 'Rochdale' process was that it seemed to offer the opportunity of making gas from a still wider range of coals, both in caking power and in size grading, when using continuous vertical retorts, which already seemed quite popular from the point of view of good operating conditions and general amenities. If it could be demonstrated commercially that a nut coal throughput could be obtained in continuous vertical retorts when carbonising coal of ¼ in.-0 in. in the form of a blend with relatively low caking index; if it further could be shown that the resultant coke was a good domestic smokeless fuel; and if finally the diluent gas for the 'Rochdale' process could be made by the complete gasification of a non-caking coal in a separate generator, then there would appear to be very interesting possibilities in the overall proposition.

It seemed to him that any process which widened the range of coals usable in the gas industry must be an advantage to the industry in its negotiations with the National Coal Board for coal supplies. This increased use of coals with lower coking properties might well be the deciding factor in the commercial value of the 'Rochdale' process rather than such matters as the possible reduction in cost of gas production or an increased output of therms per pound of capital expended, which were rather stressed in the paper.

Regarding the detailed technical information in the paper, he felt rather in the position of one who went to the cinema and saw what he believed was called the 'trailer' of next week's big picture. One watched the trailer without any particular desire to criticise details, but with a view to deciding whether the big picture was worth going to see. One rather expected to find that the trailer glamorised some of the situations and excited one's interest in possibilities which might or might not be forthcoming as the big picture unfolded. His interest had been aroused to the extent that he had been fortunate enough to secure a good seat in the showing of the big picture—which concerned the commercial-scale tests on the 'Rochdale' process planned for Partington in the immediate future. He did not want to comment at this stage on any of the authors' detailed findings, especially because they had had the courage and enterprise to subject their findings and their opinions to commercial-scale operation wherein the costs of gas manufacture, the gas meter, and the calorimeter would be the final arbiters of their investigations.

Advantage of Internal Heating

Mr. **J. T. Haynes** said he counted it a special privilege to come as President of the Institution of Gas Engineers to a meeting of the Manchester and District Section, of which he was formerly a member. Having studied the paper, the thing that appealed to him more than anything else was the sense of thrill that two juniors of 20 years ago must feel at the result of the work they did; he referred to Mr. Bamber and Mr. Smith, who were members of his staff at Bolton at that time. It seemed to him that the juniors of today might well have the paper put before them to illustrate some of the possibilities for the younger men in the industry.

Internal heating of the charge was not a new idea; it was one of the advantages claimed for the old Tully plant which he operated 30 years ago. In order to ensure safety and correct working of the 'Rochdale' system it was necessary to have interlocking gear, valve control, automatic control, and a whole list of controls as set out in the paper. In contemplating future large-scale developments he wondered whether it was going to be simpler to put down two or three units of the complete gasification type, or to have 30 retorts each of say 250,000 cu.ft. per day, each having its own automatic gear. It seemed to him that the 'Rochdale' system was going to be restricted to increasing the capacity of existing plant rather than being incorporated in new plant. Its greatest advantage, as Mr. Finlayson had pointed out, would be its capability of making gas from a wider range of low grade and small coal.

It seemed to him that in pushing the hot gas up through the charge they were, in effect, carrying out low temperature carbonisation in the centre of the charge, with a certain amount of high temperature carbonisation from the walls. If they could do that with lower combustion chamber temperatures, why use refractories at all? Their object was to prevent transmission of heat, and if they could get down to combustion chamber temperatures sufficiently low to be handled by metals it might be worth while considering the possibility of getting back from refractory to metal retorts.

He did not propose to enter into any criticism or comment on the technical aspects of the paper. He felt everyone in the gas industry would appreciate the work which the authors had done, and in offering them his congratulations he expressed the hope that they would attain even more satisfactory results in the future.

Mr. **Nicklin,** replying to Mr. Haynes, drew attention to the fact that the gross cost per therm of producing approximately 4 mill. cu.ft. of gas per day, employing the complete gasification process using heavy oil carburetting, was 8.71d., while the 'Rochdale' process with blue water gas injection, showed a corresponding figure of 7.28d. He could not agree with Mr. Haynes' suggestion that the 'Rochdale' process was limited in its application to existing plant. While the gross cost per therm in a new installation of continuous vertical retorts was given as 10.03d., there was the advantage of the lower capital cost for complete gasification gas on a higher gas output. On the question of the mechanism of carbonisation he believed the temperature of carbonisation was not any less than that involved in the carbonisation of coal at present. They were employing convection, which was better than conduction. Low temperature carbonisation was probably in Mr. Haynes' mind because of the suggestion that they could work at lower retort temperatures, but that did not mean any lower temperature of carbonisation.

Mr. **M. Sinclair Gaskell,** Technical Director, West's Gas Improvement Co., Ltd., said he had been closely associated for some time with investigations on similar lines to those described in the paper. The process was not new—in fact, he believed the passing of gas into horizontal retorts was practised as long ago as 1860. The West and Perkin process for introducing gas into continuous vertical retorts was described in a paper given to the Southern Association of Gas Engineers and Managers in 1917, but at that time and for many years

it was, for economic and other reasons, less advantageous than the steaming process. The economic background of the gas industry, particularly since the second world war, had changed rapidly, and it had become imperative to examine not only new methods of gas manufacture but old and possibly at one time uneconomic methods in the light of present-day conditions.

It was known from the work of the late Mr. John West and the later investigations of Mr. Smith at Bolton that the transfer of heat from coke to coal in a continuous vertical retort by means of a carrier gas resulted in an appreciable increase in throughput. Recent investigations were therefore directed to the examination of the practical application of the process and the determination of the best type of carrier gas to meet the industry's requirements and the effect with various types of coal.

Effects of 'Carrier Gases'

The 'carrier gases' so far employed had been producer gas, water gas, coal gas, and mixtures of coal gas and water gas. The coals carbonised had been sized Yorkshire, Scottish, and Welsh coal, and Yorkshire and Durham slacks. It was hoped to publish results in due course, but in the meantime a brief summary might be of interest for the purpose of comparison with and confirmation of the authors' results. With Yorkshire coal using producer gas as the 'carrier gas' an increase in throughput of 125% and in thermal output of 54% was obtained when making gas of approximately 450 B.Th.U. per cu.ft. as compared with steaming under similar conditions. The thermal yield per ton of coal was reduced, and the inert content of the resulting gas was high. In the case of the Scottish and Welsh coals blue water gas was used as the carrier. With the Scottish coal the increase in throughput and thermal yield were 112% and 113% respectively, while the Welsh coal gave increases of 91% and 88%. The thermal outputs included the 'carrier gas.'

When coal gas and mixtures of coal gas and water gas were introduced as the 'carrier gas,' while similar increases in throughput were obtained considerable degradation of the 'carrier gas' occurred with resulting loss in thermal yield. The loss was somewhat greater than that shown in Tests 5 and 6 in the paper. When using coal gas as a carrier gas the volumetric output per retort—*i.e.*, the gas to be dealt with—exceeded the actual make by the volume of the re-cycled gas; moreover, it would be necessary to introduce a diluent gas at a later stage to obtain the desired calorific value. In regard to the carbonisation of small coal two series of tests had been made using producer gas with Yorkshire and Durham slacks. The Yorkshire slack contained approximately 73% below ¼ in. and 27% below $\frac{1}{16}$ in. With the Yorkshire coal making gas at 450 B.Th.U. an increase in throughput of 64% was achieved as compared with steaming to approximately the same calorific value. With Durham slack of which the screen analysis was 82% below ¼ in. and 27% below $\frac{1}{16}$ in. an increase in throughput of 63% was obtained. These figures were comparable with those given in the paper and certainly confirmed the possibilities of the application of the process to the carbonisation of low-grade coal.

The Merits of Blue Water Gas

No investigation had yet been made into the use of complete gasification gas, but from the results of those already carried out with mixtures of water gas and coal gas there was little doubt that thermal loss due to cracking would occur with such gas. While in certain cases the use of other gas might be justified on economic grounds it would appear that blue water gas was the most suitable 'carrier gas.' There were a number of interesting aspects of this process, but he would comment only on two—the effect on the tar and coke. In their investigations the increase in tar yield was greater than that found by the authors. The tar was of a similar nature but there was some indication that both the yields of tar and its composition were functions of the rate of 'carrier gas' input relative to coal throughput; in fact the relationship between volume of 'carrier gas' and coal throughput had a critical effect on several aspects of the process.

In regard to coke, their results on the whole confirmed those given in Table 6—*i.e.*, that the effect of the process on coke reactivity was very small. Such variations in reactivity appeared to be more probably due to variations in the volatile matter content of the coke. Their experience of the result of the process on the screen analysis of the coke indicated that, while the process had a definite effect, the nature and extent of such effect depended to a large extent on the type of coal carbonised. It was noted from Table 6 that the minimum breeze content was obtained when carbonising coal of the lower volatile content and highest swelling number.

Their investigations were carried out at somewhat lower combustion chamber temperatures—*i.e.*, about 1,300°C.—than those used at Rochdale. In that connection the potentialities of the process for carbonising at low temperatures were interesting. Experiments carried out in another connection many years ago indicated that nominal throughputs could be maintained at temperatures of about 1,000°C., and it was proposed to pursue that line of research. As to the ecenomics of the process, while in certain cases definite improvements could be obtained, the extent of such improvements must be related to, and considered subject to, conditions and requirements in each individual case. He would underline the authors' statements in regard to the method of application and control of the process. While the proposed system of control of gas admission would appear to be somewhat elaborate it was essential in view of the nature of the process that adequate precautions should be adopted.

Pioneer Work at Bolton

Mr. **W. P. Smith**, Engineering Assistant, East Midlands Gas Board, thanked the authors for their reference to the pioneer work carried out at Bolton in 1930. That work was carried out at the instigation of his father, the late W. J. Smith, a past President of the Manchester and District Association of Gas Engineers. The work was under the direction of Mr. C. H. Bamber, now Group Manager of the Oldham-Rochdale Group, and Mr. D. Benson, now at the Bradford Road works, was another member of the team. In their reference to theoretical considerations the authors had expressed surprise that investigations into the process of gas injection had not been carried further. The value of the process depended very largely on the reduction in capital cost per therm of the additional gas required. In 1930 capital costs were very much lower than they were today, and the gain from the process at that time was slight, while the coal to coke price ratio was not very favourable.

The gas injection process responded more rapidly to any changes in operating conditions than did the normal carbonisation process and, just as technical staff were found to be necessary over the 24 hours in the early experimental runs, he felt it was equally necessary that technical staff should supervise the process over the 24 hours when the system was applied to a bench of retorts if the maximum benefit was to be obtained.

The Bolton test plant was fitted with a butterfly governor operated by an Arca relay. The governor was very sensitive and thus reduced the loss of gas due to top pressure when purging steam was turned on. The authors rightly drew attention to the fact that, when operating the process on a bench of retorts, a rapid response to variation of pressure conditions in any one retort could not be expected. In designing the discharge interlocking gear he suggested that increased pressure at the time of the steam purge could be avoided by arranging that as the steam was admitted the quantity of injected gas was correspondingly reduced. There did not seem to be any particular reason why the full steam purge and normal gas injection should operate at the same time.

Attention had been drawn to the fact that the labour of rodding was reduced due to increased rate of coal travel and the apparent absence of the plastic layer; and also to the fact that unless rodding was correctly carried out, uneven travel of the charge might, and probably would, occur. This confirmed the findings at Bolton where they were interested to note that, whereas under steaming conditions the retort took three-quarters of its coal at rodding periods, with gas injection three-quarters of the coal—now double the original amount—was taken between rodding periods; that meant that coal travelled further down the retort without the control of the rod. The authors had said a second offtake was not required, but it was possible that, with a more even distribution of gas in the upper sections, the tendency to form cavities might be reduced.

While the process would give a material increase in the coal throughput of many slack coals it must not be assumed that all slacks could be carbonised in vertical retorts using this process. Certain slacks at Bolton caked seriously and almost completely blocked the flow of gas through the retort. The blending of slack coals envisaged by the authors was a very wise precaution and would materially increase the range of slacks which could be handled, if and when they became available.

The degradation stated to occur in the steaming bell section of the retorts at Bollington using re-cycled gas was not unexpected, and he looked forward to hearing that the elimination of this section would overcome the trouble. The reduced therms from the coal in tests Nos. 5 and 6 compared with test No. 4 indicated that some loss was occurring during those tests at Rochdale. The authors had not stated whether any carbon black was found to be present on the coke during the tests; such a condition would materially influence its reactivity.

Technical Control

Mr. **Nicklin**, replying to Mr. Smith, said they felt technical control of retort house operation should be present at all times; it should be on a 24-hour basis in order to obtain the best

results. They saw no reason, however, for additional technical control for dealing with gas injection. It was so flexible and so easily achieved that one of the senior assistants in the department could change over from steam injection to gas injection simply by turning two valves. They did not think any modification in the offtakes of the retort was necessary.

Mr. **Redman** emphasised that the main advantage of the 'Rochdale' process was that it offered cheap gas on an expanding load. There was no need for a second offtake when the retorts were working simultaneously.

'Startling Results'

Mr. **W. A. Evetts,** Watford Divisional Engineer, Eastern Gas Board, said the heavy capital cost of new carbonising plant, together with the continuing increase in the price of coal delivered to works, and the competition from alternative fuels, electricity and oil, had brought about a situation which was concerning the gas industry more than at any other time in its history. Revenue from by-products, in particular coke, had not kept pace with increased coal costs, as, in present circumstances the price of coke must be closely related to the price of coal. In some quarters it was felt that coke would stand a substantial increase in price provided quality and grading were improved and consistent. The public had not yet got used to treating coke as a processed fuel, still tending to look on it as the residue of the coal when the gasworks had extracted the best parts from it.

The search for alternative means of producing gas from coal and oil had been treated as a matter of urgency both here and on the Continent, and a considerable measure of success had been achieved, perhaps particularly on the Continent. The acceleration of the carbonisation process by injecting gas instead of steam into continuous vertical retorts could be placed high on the list of those new methods. Although in the main the paper dealt with the Rochdale trials and injection of gas carried out on two retorts, the results were so startling as to remove any serious doubt that similar results could be obtained on a large scale, and gas engineers generally looked forward with intense interest to the experiment to be started at Partington.

He was particularly interested in the authors' references to complete gasification and their assessment of the cost of producing gas by that process. They estimated that complete gasification with heavy oil enrichment would produce the lowest cost per therm, including capital charges. Those who attended the International Gas Congress at Brussels in 1952 heard a paper on complete gasification by Professor Giourdano, Gas Engineer at Naples. It was obvious that much progress had been made on the Continent with the Gaz Integrale process, and in a short report to the Eastern Section of the I.G.E. in November, 1952, he (Mr. Evetts) drew attention to the apparent economics of the process compared with carburetted water gas and coal gas production.

An Established Process

Costs quoted by the authors should be viewed in the light of conditions prevailing in the North West and the prices of coal and coke. The authors had emphasised that and had included sufficient information to enable comparison to be made of the two processes with differing prices for coal and coke. A number of British gas engineers had inspected the Gaz Integrale plant at Vierson in France, and it was fairly evident that complete gasification was an established and successful process. Due to the high cost of coal in France it was not so attractive in that country as gas from heavy oil, but with the prices prevailing in the South of England, with which he was more familiar, the opposite was the case. In a new installation it would certainly appear to be more attractive to re-cycle a gas from complete gasification plant rather than producer gas.

He wondered if the authors had considered using a lower rank coal with presumably a lower cost for complete gasification. That, he thought, was where the process assumed still more value—*e.g.*, in the Watford area, West Midlands coal suitable, they believed, for complete gasification was about 17s. per ton less than South Yorkshire coal. Probably there was a coal almost on the doorstep of Rochdale, which would be suitable for the process.

He had also been able to pay a visit to Cahors to see the Onia-Gegi plant at work. That process had also established itself as an extremely satisfactory way of producing gas from heavy oil, although Gaz de France were of the opinion that the carbon content of the fuel oil should not be greater than 10%. Their No. 2 fuel oil was rather better gas-making material than 950 sec. fuel oil obtainable in this country; it contained less of the cracked products from the refinery, but it was doubtful whether that situation would continue for long.

It was an exciting time and they would be happy to feel that these processes, which he believed were more complementary to one another than alternatives, would be available. Over the next few years it should be possible to increase considerably the amount of coke available for sale from suitable coals if there was a demand for that fuel. They had heard that the Minister of Fuel and Power was asking the gas industry for another 1 mill. tons of coke and the public was becoming smokeless-fuel minded, and it might be part of their salvation to pursue with vigour the expansion of coke sales.

Had the authors considered the preheating of the injected gas by a suitable method of recuperation or regeneration? It would appear that on a new installation of continuous vertical retorts it would be more economical to preheat with waste gas the injected gas, than to use the waste gases for making steam. The authors' suggestion that the complete gasification gas might be enriched by the installation of a separate oil gasification or cracking plant had much to commend it, particularly if a catalytic cracking process were adopted, because by such a process they might obtain an increase of about 25% in the thermal yield from the oil.

The Coal-Coke Price Ratio

Mr. **Nicklin** said the relationship between the cost of complete gasification gas and the cost of coal gas in vertical retorts was entirely a function of the ratio of coal price and net revenue from coke sold. Probably in Mr. Evetts' area coke demanded a very high price and the ratio was such that complete gasification gas was more economical than coal gas in vertical retorts. With regard to low-rank coals, there were large quantities in and near the North Western area, and those were the coals they were proposing to use. He could not agree with Mr. Evetts that the gas injection process tended to increase the coke available for sale. Surely if it was used in conjunction with complete gasification plants the coke market could be controlled by using either coal or coke at the complete gasification plant.

Mr. **S. L. Wright,** Gas Engineer, Wales Gas Board, said every contributor to the discussion would want to pay tribute to the authors, and he wanted to add not only his own personal appreciation but that of the Wales Gas Board for this timely and informative pointer to a means of achieving economies in operation of their carbonising plants with limited additional capital expenditure. The pains the authors had gone to in describing their experimental procedure and the difficulties they had encountered could not fail to be of the greatest possible benefit to those who would now want to take advantage of the work they had already done. The details of the large-scale operations to be undertaken at Partington were a particularly generous contribution to the gas industry's knowledge of this development.

He was particularly interested in the results obtained in the runs numbered 4, 5, and 6, where gas was injected at a rate of 5,000 cu.ft. per hour. He noted that this was equivalent to between 9,400 and 10,000 cu.ft. of injected gas per ton of coal carbonised, with an increase in coal throughput 1.91 to 2.03 times that of run No. 1 when the gas was steamed down to 462 B.Th.U. Calculations based on run No. 4, in which 9,700 cu.ft. per ton of producer gas gave a final gas of 373 B.Th.U., showed that that quantity of blue water gas would have produced a final gas of 455 B.Th.U.

The use of producer gas with re-cycled gas enrichment would require 4,240 cu.ft. of producer gas and 5,460 cu.ft. of re-cycled gas per ton of coal to give a final gas of 470 B.Th.U. without air dilution. Some preliminary tests carried out on Gresford coal in the coal test plant at the works of West's Gas Improvement Co., Ltd., with injection of blue water gas had shown that with that particular coal a blue water gas admission rate of 10,314 cu.ft. per ton gave a final gas of 461 B.Th.U., with a coal rate increased 1.8 times compared with the rate when steaming down to 457 B.Th.U.

The Question of Heat Requirements

In view of the fact that the process depended on the return of the heat from the coke leaving the retort to the coal charge in the retort it was feasible that there must be some increase in the heat supplied to the retort from the normal heating flues if the coal throughput was increased. Tests on individual retorts in a bench of retorts did not enable producer fuel determinations to be made, but the estimation of the increased heat requirements by observation of damper positions to which the authors had made reference showed that this determination was not being overlooked.

The authors had pointed out the economic advantages of the process with stimulating references to alternative sources of injected gas. The process must be particularly attractive to those works where continuous vertical retorts and water gas plants were already installed. It was obvious under those conditions that each case must receive individual consideration. Integration of undertakings provided a means for disposing of additional quantities of gas from undertakings that were most economical to run. A paper such as this revived the

true gas engineer's regret that that same integration resulted in so many works ceasing to produce gas.

The 'Rochdale' process appeared to combine the principles behind complete gasification in a Tully plant with those of continuous carbonisation, in that the coal in the retort was heated externally by a continuous supply of producer gas to the combustion flues and internally by a carrier gas preheated by the coke produced in the retort. Was it beyond the range of practicability to visualise a combination of complete gasification and continuous carbonisation retorts in one bench whereby the complete gasification retorts provided the injected gas for the continuous carbonisation retorts and also supplied hot fuel to the producers for heating both complete gasification and continuous carbonisation retorts. The sources of heat loss in supplying cold coke to retort setting producers and to blue water gas plants would thereby be avoided.

Mr. Wright added that the paper was of such interest to the gas industry that he hoped the Technical Press would do the fullest possible justice to the authors; he suggested also that additional copies of the paper itself might be made available for circulation.

Mr. **W. R. Garrett,** Chief Constructional Engineer, Northern Gas Board, said the thanks of the industry were due to the North Western Board and its experts. As against the 70% continuous vertical retorts in the North West, they had only about 15.8% of their gas-making capacity in the Northern area in the form of continuous verticals, largely because they purchased nearly 50% of their gas from the coke ovens. He wondered whether the authors had not over-stressed the question of gas price for new works. There were very few completely new works being built today. As a matter of interest he had lately checked up on the verticals in the new works extension at Stockton, and the capital charges worked out at 1.4d. per therm. The figure covered the carbonising and ancillary plant, but not gasholders, offices, purchase of land, and that sort of thing.

In view of the experiments the North Western Board had carried out he wondered whether the authors could give some idea of what they would expect to get if they were carbonising Durham coals in a modern installation. Was any allowance made in their figures for increased labour at the top of the retorts and for handling the increased output at the bottom.

While the paper would go a long way in helping towards the production of cheaper gas he suggested that they should not lose sight of the fact that many millions of tons of heavy oil were coming on to the market. It might pay the gas industry to consume more of it rather than allow it to compete with industrial gas. It was an important factor that should be borne in mind when considering this paper.

The Incidence of Capital Charges

Mr. **Nicklin** said that on the question of capital charges Mr. Garrett was thinking in terms of an extension on an existing gasworks site, involving no extra holders or services. Most people when they wanted to increase their plant had to look round for a new site. The figure they had from the contractors was the figure given in the paper—1.4d. per therm, in addition to which there would be the cost of the gas for injection. They would expect a relative increase in throughput when carbonising Durham coals, subject to the swelling characteristics of the coal. As to labour costs, there would be extra labour for coke discharge due to increased regularity in coke withdrawal, and also for labour on the top to ensure that the retorts were running freely. In regard to the heavy oil position, they claimed that there was a case for the use of heavy oil in connection with complete gasification. Continuous vertical retort gas should form the bulk of their gas production, and peak load gas should be met by centralised catalytic oil cracking methods.

Mr. **C. Johnson,** Coal Officer, Gas Council, said the authors had presented the results of their initial investigations with admirable clarity, and the possibilities of the technique which they had discussed made a very fascinating picture. The prospect of reduced capital charges and operating costs was in itself a sufficient inducement to encourage further investigational work. The added prospect of being able to employ conventional, or even new type, gasification plants using coal, coke, or oil as a source of supply of circulation gases was very attractive and appeared to offer great flexibility in the manner of providing the total daily requirement of gas. The inference was that by the technique suggested in the paper considerably more coal could be carbonised in continuous vertical retorts, and that by the general adoption of this technique considerably more use would be made of continuous vertical retorts as the means of providing the main source of gas supply.

Incentive to Install C.V.R.

About half the coal carbonised by the gas industry today was processed in continuous vertical retorts—*i.e.*, about 14 mill. tons a year. Horizontal retorts accounted for about one-third of the total coal carbonised, and intermittent vertical chambers and coke ovens accounted for the remainder. A considerable reduction in the number of horizontal retorts in use was envisaged over the next decade, and it might well be that if such a technique as had been advocated that day proved worthy of adoption there would be a new and attractive incentive to install continuous vertical retorts as the favoured type of replacement plant as obsolescence overtook existing retort systems.

The present output of carbonisation coal, assuming it was defined as coal falling within the quality ranks 301/600, and excluding coals of a higher ash or sulphur content than the carbonising industries would elect to use, was at least 70 mill. tons a year. The present requirement of the carbonising industries was 53 mill. tons a year, made up of 27 mill. tons for the gas industry and 26 mill. tons for the coking industry. At least a quarter of the total tonnage of coal occurred as large coal, and this was immediately scalped at the collieries, mostly for traditional house coal and locomotive purposes, and with a complete disregard for its value as carbonisation coal. After taking into account the requirement of unscreened gas coal there was, however, an annual availability of graded carbonisation coal of acceptable quality down to ¼ in. size of at least 15 to 16 mill. tons, or at a lower size limit of ¼ in. of about 25 mill. tons. There was also available 20 to 30 mill. tons of smalls, according to the top size selected, of acceptable quality which provided the main source of supply for the coking industry. It was a lamentable fact that a considerable quantity of carbonisation coal, much of which would be acceptable to the gas industry, found its way into other markets where its place could be taken equally well by coals of a different type. At the same time a substantial quantity of low rank coal, although not necessarily low quality coal, found its way into the carbonising industries.

The total coal requirement of the gas industry 10 years hence was estimated to be 30 mill. tons and, if due allowance was made for the unscreened element, about 20 mill. tons would need to be provided as graded coal. Apparently this should be feasible. There were two parties concerned with making available the right tonnage of the right kind of gas coal—the National Coal Board and the gas industry itself. The National Coal Board would have to be convinced that the carbonising industry must have first claim on carbonising coal. Perhaps the gas engineer, equally, would need to be convinced that continuous vertical retorts were in fact much more catholic in their choice of coal sizes than were their masters. Furthermore, the time had arrived when they must consider whether closely graded best-quality carbonisation coals still needed to be charged into horizontal and intermittent vertical chamber systems.

He mentioned this for two reasons. First, the greater the pressure on the Coal Board for closely graded gas coal, the greater the incentive to increase gas coal prices. Secondly, there would appear to be no obvious need for the authors of the present paper to consider blending low rank coals of low thermal content, or the carbonisation of slacks. Weighing coal price savings against lower gas outputs, it seemed that a close examination of all the likely benefits was called for in the absence of any single outstanding advantage, other than flexibility.

Facts of Outstanding Importance

Mr. **D. J. A. Mansell** (Tully, Sons & Co., Ltd.) described the paper as an epic contribution to the knowledge of gas manufacture. Pioneers, like evangelists, he said, were seldom acknowledged in their own time; usually they were in advance of their fellows. It required an equal spark of genius to reclaim a process from the scrap heap of discarded ideas and use it to solve a particular condition. The authors had put forward a practical method for increasing the output of existing continuous vertical retort installations which at the same time allowed a good quality coke to be manufactured from poor quality coals. Those facts in themselves were of outstanding importance to the gas industry as it was constituted at the present time, and would enable many problems to be solved economically with speed.

He personally congratulated the authors on their recognition of the economies afforded by the application of complete gasification. His company was intimately connected with the field of complete gasification, and had pursued that claim for many years, despite a tendency of the industry in general, although not in particular, to discard the process to the scrap heap. He felt the industry should carefully consider the use of complete gasification plants and examine all the advantages of flexibility and economy which were obviously available, bearing in mind all the other economic factors that applied to any particular installation.

The authors had outlined a proposed system of gas manufacture that should meet the fluctuating demand conditions of the main product—gas—as well as the fluctuating supply and demand conditions of the basic coal, the by-product coke,

and the imported oil. The paper contained much detailed information, and some of the details were open to considerable discussion, but the principles involved in this improved system of carbonisation were of such basic importance that discussion of the variable details was of little moment at this juncture.

The varying conditions of site, labour, raw materials, and many other factors gave rise to great variations from works to works; consequently it would be foolish to agree that the proposals put forward would solve all their present problems, but it was reasonable to assume that the basic concept would eventually allow them to employ hitherto non-coking coals and thus solve a national problem. The acknowledgment of low-pressure complete gasification was a further step towards the greater use of our main coal resources. He ventured to suggest that the integration of continuous vertical retort carbonisation and complete gasification as outlined by Mr. Wright earlier in the discussion was one development that would assist in the greater use of low grade coals.

Flexibility

Some 20 to 30 years ago the Tully Company installed complete gasification plants used in direct conjunction with a form of vertical retort, and recently it had given serious consideration to a similar system for an overseas customer. It was possible to operate a Tully complete gasification plant so that the resulting gas had higher calorific value than the 330-340 B.Th.U. usually quoted. Such a system of operation was uneconomic due to the high thermal loss in the blow gas. If, however, the available heat in the blow gas was used to heat a vertical retort the overall efficiency of the system could be maintained between 70% and 80%, and a variable quantity of gas could be manufactured economically up to 450 B.Th.U. per cu.ft. To produce a gas above 400 B.Th.U. additional heat was required for vertical retort carbonisation which could be obtained by burning blue water gas for the complete gasification process or by the use of producers. The system offered a considerable degree of flexibility together with a variable coke output depending on the method of operation of the complete gasification generator. The industry, he suggested, would now have to reconsider the fundamental design of new continuous vertical retort plant, bearing in mind the factors now proved and the relative advantages of blue water gas, carburetted water gas, complete gasification, and carburetted complete gasification.

Encouraging Results

Mr. **S. K. Hawthorn** (Birmingham Divisional Engineer, West Midlands) said that at a single reading it was difficult to form an overall appreciation of the merits of the process of injecting gases into the base of a continuous vertical retort. A great deal of experimental work had been carried out and comprehensive data were given relating to the various tests, but he felt more information would be required before the new process was proved practically and economically, although the signs were very encouraging.

In the tests reported, the injected gas had been either producer gas at 114 calorific value, a station gas (presumably coal gas or mixed complete gasification and carburetted water gas) of 467 B.Th.U., or a rich re-cycled gas of 600 B.Th.U., while the total gas produced had been of a calorific value of between 347 and 600, but none had been near a calorific value of 450, which would probably be required for distribution. Leakage of gas from bottom castings had obviously been a real problem so that results obtained had had to be corrected for an estimated loss by leakage.

It was obvious that the internal heating of the charge with injected gas had accelerated the carbonising process, and that must result in a reduced fuel consumption, although the authors had not been able to assess the saving. The actual figure was of paramount importance in arriving at the true cost of gas production. The figures revealed a small increase in H.E.V. and a substantial increase in tar—*i.e.*, more enrichers *and* more tar, which was unusual, but which could be explained by less scurf formation. The authors did not claim less scurf formation although it was implied when they stated that the latter was the same with much higher throughput.

It was interesting to note the reduction in the proportion of coke below ¼ in. as compared with normal continuous vertical retort practice; that must be considered a distinct credit to the new process as the overall return from coke would be greater. If producer gas were decided on for the injection gas it could be made with the sizes ¼ in. to ¼ in. and would be useful as an outlet for those sizes. Comment had been made on the effect of the coal charge hanging up when working at very high throughput. If that occurred the risk of damage to refractories was increased over normal throughputs; it would be important to ensure solid charges.

Recirculation of coal gas as an alternative to producer gas did not appear to be attractive, partly because leakage at bottom castings would represent a greater loss and partly because of the probable degradation of hydrocarbons. The authors had concluded that it would be best to develop their process using blue water gas or complete gasification gas, but he had some doubt whether blue water gas would prove economic. The quantity of blue water gas would be about half the total gas, and he calculated that this would absorb all the large coke made over 2 in. and half of the 2 in.-1 in. size, which would leave a preponderance of the lower sizes for sale at probably a lower price. Blue water gas was rich in hydrogen. Would there be any reactions between the hydrogen and the coal to form condensible hydrocarbons and thus reduce to some extent the gaseous hydrocarbons? The mixed gas using blue water gas would contain 27%-28% CO.

On the vital question of costs of gas production the authors presented a most attractive picture, but they were not given a full breakdown, particularly as regards coke available for sale. Some other items might be a little over-optimistic. He found it hard to believe that the extra gas could be made for 5½d. a therm or 6½d. including additional capital. Although additional gas would be obtained from the same retorts, additions would be required to coke plant, exhausters, washers, purifiers, meters, etc., and probably larger mains would be required.

The suggested carbonising of blended slack coals was one of the most attractive features of the new process, and the industry would be interested in the outcome of the trials.

Mr. **H. Johnston,** Senior Vice-Chairman, proposed, and Mr. **J. Wilson** (Manchester) seconded, a vote of thanks to the authors.

Mr. **Nicklin,** in a brief acknowledgment, said one of the earlier speakers had remarked that it spoke well for the North Western Gas Board that it allowed the results of this work to be published before its final completion. The reason was obvious—it was better for hundreds of people to do the same job than for one or two.

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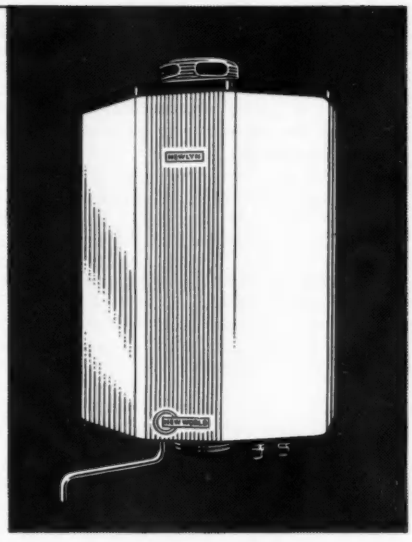

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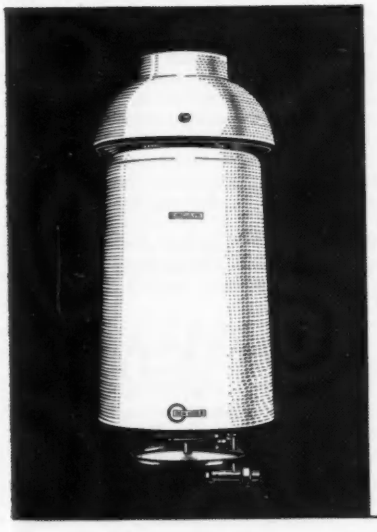

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RESEARCH, DEVELOPMENT, AND DESIGN

AN ADDRESS AT A JOINT MEETING OF THE EASTERN AND WESTERN DISTRICTS OF THE SCOTTISH JUNIOR GAS ASSOCIATION, GLASGOW, MARCH 6, 1954, BY

W. K. HUTCHISON,

C.B.E., Junior Vice-President, Institution of Gas Engineers; Chairman, South Eastern Gas Board.

The creative part of an engineer's task may be overlooked among the duties of production, distribution, and routine maintenance which demand his first care. The title of my paper directs attention to three stages through which it is necessary to pass on the way to the creation of new enterprises.

In the gas industry research is now receiving much greater support than ever before. The responsibility for research lies with the Gas Council, and the Gas Council, through its Research Advisory Committee, settles the programme and directs policy; but it is the area boards who have the final responsibility for applying that research in the design and operation of plants which they control. The Council has established two research stations, each of which is located in, and managed by, an area board, and it supports approved research projects carried out by other area boards. In this way it has done what is possible to ensure that research is directed along practical lines, and that facilities are at hand for the further development of results obtained.

The Gas Council is also maintaining the close collaboration which has existed for many years with the Fuel Department at Leeds University. We may see in developments at Leeds a recognition of the need for background research deriving its strength from close contact with a university. You will know, too, of the scheme for research scholarships under which five scholarships are to be awarded each year among certain nominated universities.

Finally, the Gas Council supports and contributes substantially to associated research bodies, and all this amounts to a very considerable research effort exceeding anything that the industry was expending before nationalisation. It will surely be to the advantage of each area board to make the fullest use within its own organisation of the results of research, and, in return, to send back to the research centres their views on matters to which the attention of the research bodies should be most urgently directed. Just as we know the difficulty which exists in carrying results from the research laboratory through stages of practical development into the design and operation of works, so I think we must appreciate the danger which arises from a lack of direction of research effort towards problems which need attention. One of the most serious difficulties in the way is lack of contact and understanding between those who practice in these different spheres.

The Aims of Research

Civilised man is not content to accept his surroundings as he finds them; he seeks to modify and improve, and is governed by a spirit of curiosity which demands to know more about the reason behind the world and its existence. Research consists of a steady direction of that curiosity, and, at the risk of over simplification, I like to think of it as directed towards the two questions—How? and Why?

The alchemists tried to achieve their results without a sufficient background of knowledge carefully obtained, tabulated, and digested. Although they acquired experience in the behaviour of metals and other substances, and developed many pieces of basic equipment still used today in laboratories and industry, their methods bore no relation to the processes of thought necessary in research.

Chemical research as we know it today began with Robert Boyle, who first enunciated the principles of expansion of gas embodied in the Law, PV = a constant, which bears his name. Boyle was a great man and an orderly thinker, and he devoted much of his time to work in his laboratory at Oxford where he distinguished himself by the accurate measurement and recording of scientific phenomena. The full explanation of Boyle's Law did not come for another century-and-a-half—he found out *how* a gas behaved, but not *why*.

Credit for the development of the kinetic theory of gases which supplies this explanation rests with a number of mathematicians and physicists working in the first half of the nineteenth century. The kinetic theory provides accurate information about the behaviour of molecules, information which has a part in the solution of almost all problems where gases are concerned. It has its roots equally in the accurate observation of natural phenomena and in the processes of abstract reasoning.

We are indebted to James Clark Maxwell, the product of a Scottish school, for some of the most brilliant work in this field leading up to the Law which bears his name, and which gives the distribution of velocity among molecules in random motion.

The transition from superstitious speculation through accurate observation to mathematical solution is seen also in the history of astronomy. The movement of the heavenly bodies had been noted and recorded well before the Christian era, but the dark age of the science is represented still by the activities of the astrologers who try to link these movements to human and terrestrial fortune.

Modern astronomy began with Galileo, who first applied the telescope to the study of the heavens. In the year that Galileo died Isaac Newton was born, and Newton fell heir to a mass of carefully observed scientific phenomena—records of the movements of the sun, moon, planets, and stars, and two conflicting theories according to one of which the earth moves round the sun, while the other postulated a stationary earth round which all the universe revolves.

By the age of 24 Newton had evolved his theory of gravitation which provided an explanation of all these observations and reconciled the conflicting theories. As Pope was to say:—

> God said, "Let Newton be!" and all was light.'
> 'Nature and Nature's laws lay hid in night.

It was not till the twentieth century that J. C. Squire had to cap this with:—

> 'It did not last: the Devil howling "Ho!"
> Let Einstein be!' restored the *status quo.*'

We should not be discouraged if theories have to be modified from time to time. Observations carefully made and accurately recorded—the answer to the question 'how?'—double in value if they can be linked together and explained by theory, even if theory which seeks to answer the question 'Why?' has in it the seeds of its own destruction. For by pointing the way to further possibilities capable of scientific test, theory initiates discoveries which in turn lead to its own modification or replacement.

Methods of Research

When a new problem has to be attacked, experimental methods must be selected and adapted to the needs of each case. One of the first principles to be observed is that variables must be isolated and their effect determined singly. This is illustrated in Fig. 1, which represents

graphically the results of an investigation into the kinetics of the reaction between bromine and formic acid in aqueous solution (*J.Chem.Soc.* 1925, **127,** 2715).

It was established (Fig. 1A) that, all other variables being constant, the rate of disappearance of bromine follows the course of a first order reaction and could be

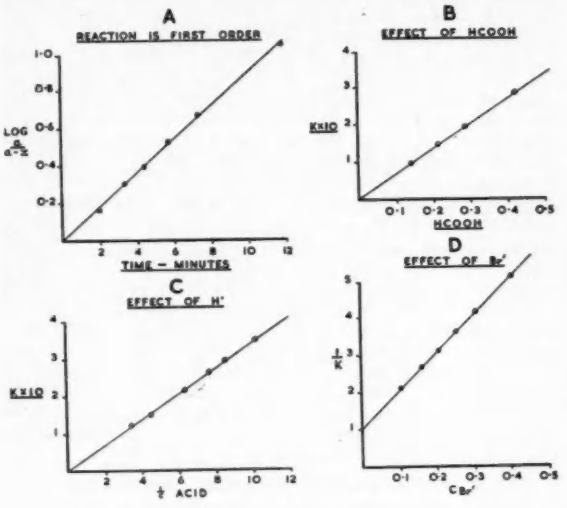

Fig. 1.—Reaction of Bromine with Formic Acid.

expressed by a single constant, K. It was then shown in turn that K varied directly with the concentration of formic acid (Fig. 1B) and inversely as the concentration of hydrogen ions (Fig. 1C). Finally it was found (after some trials) that the reciprocal of K was a linear function of the concentration of bromine ions. The conclusion, based on certain known facts about the nature of the solutions involved, was that the reaction occurs between free bromine molecules (*i.e.*, those not combined with bromide to form a tribromide complex) and formic ions.

This first example does not go beyond the attempt to establish a few facts about the course of a reaction, and much more importance should be attached to investigations which seek to determine the underlying causes. It is therefore more profitable to study rate of change in gases because kinetic theory provides essential information about the state of atoms and molecules. A problem of very long standing was to determine why reactions go at measurable speed—why, in fact, only some molecules at any one time are predisposed to undergo reaction, and not all, or none. It had become fairly well established that reaction was closely related to the distribution of energy among molecules and that only those molecules which acquire energy in excess of some critical value, E, appear to be able to undergo change. Clark Maxwell's Law in a simplified form gives the number of these as

$$\frac{N_1}{N} = e^{-E/RT}$$

where N_1 is the number of molecules out of a total N having energy in excess of E. This agrees with the observed effect of temperature on rate of reaction, which follows the form

$$k = Ce^{-E/RT}$$

$$\text{or} \quad \log k = A - \frac{E}{RT} \qquad \text{(cf Fig. 2)}$$

Whereas for reactions of the second order (bimolecular) there was quantitative agreement between E as determined experimentally and the value of E deduced from Maxwell's Law, an anomalous result obtained in the case of the only homogeneous first order (unimolecular) reaction known in 1925. The effect of temperature was of the above general form, but the maximum rate at which molecules could acquire the energy E was very much less than the number actually known to react.

In pursuing a problem of this kind research must be directed towards the discovery of material for further theoretical study. Examples have to be sought out rather for the light they throw on the underlying mechanism than for the intrinsic value of any information about their nature and course. Thus the decomposition of acetone proved to be of the first order and confirmed that the number of molecules reacting was 10^8 as great as the number predicted by Maxwell's equation, while the apparently similar decomposition of acetaldehyde proved to be of the second order and the number of molecules reacting was in good agreement with the predicted rate. (*Proc.Roy.Soc.* 1926, **111,** 245 and 380).

This anomaly was later resolved by allowing for energy involved in the internal movements of the molecules as additional to energy involved in simple collision, and this in turn set in train further investigations which discovered an unexpected complexity and takes the subject well beyond what can be described in this brief statement (cf. Hinshelwood's *Kinetics of Chemical Change,* O.U. Press, 1949).

Industrial research may well involve an examination of underlying causes, but generally it will have to be directed towards a more immediate objective, either to find out new ways to carry out some desired operation or to provide a solution of some operational difficulty. The investigations into the occurrence of gum and its causes carried out under the direction of Mr. H. Hollings at the Fulham Laboratory in 1935 and described in detail by him (*Trans.Inst.Gas E.* 1936/37, **86,** 501) constitute an example of research of the latter kind.

It was established that nitric oxide is normally present in sufficient quantity at the inlet of gasholders to be capable of forming a significant quantity of gum. Gas entering the holders was, practically without exception, free from gum, but the extent to which gum appeared in the gas at the outlet of the holders depended on quite a number of factors which had to be disentangled one by one. With saturated gas the gum content is low, with dry gas the gum content is high. The explanation of this was shown to lie in the higher rate of settlement of gum particles weighted with water under saturated conditions as compared with the much smaller and lighter gum particles which exist in dry gas.

Laboratory conditions failed at first to reproduce the homogeneous conditions which almost inevitably must

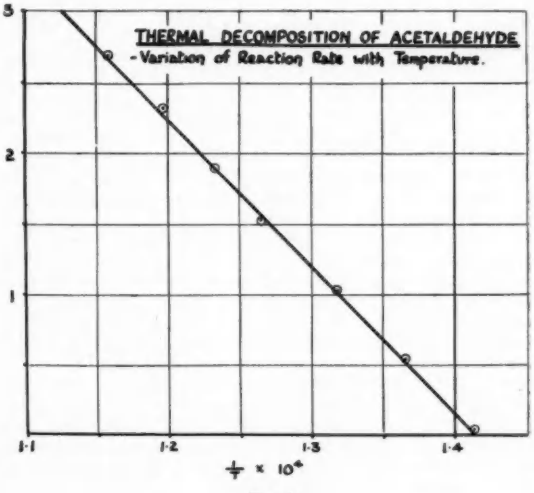

Fig. 2.

exist in a large gasholder, but satisfactory results could be obtained by using as reaction vessels a number of 10 cu.ft. test holders. A large number of experiments were made using artificial mixtures of nitrogen, oxygen, nitric oxide, and one or other of the unsaturated hydrocarbons which it was believed were taking part in the reactions leading to gum formation, the variables being isolated and investigated one at a time.

The rate of disappearance of nitric oxide does not follow any of the simple orders of reaction but exhibits

an induction period during which the nitric oxide content remains more or less constant, followed by a short period of very rapid reaction during which most of the nitric oxide disappears, and finally a period of slow reaction when the nitric oxide content is low. The length of this induction period was dependent on the oxygen content in the gas and on the concentration of active hydrocarbons, but was independent of the nitric oxide content.

The explanation of the induction period was that an intermediate product, probably a diolefine-nitric oxide complex catalysed the reaction. The catalyst, being itself a reactant, finally disappears at a rate greater than its formation, and the reaction dies out.

This view was substantiated by the ingenious method of discharging three-quarters of the contents of a test holder at the point of maximum reaction and filling it up again with unreacted mixture. The new mixture proceeded to full reaction without passing through an induction period. All this has great significance in connection with the correct operation of gasholders and distribution systems and the layout of gas drying plants, and the investigations described solved in a comparatively short period a problem which might have taken many years to elucidate by less intensive methods of research. The research worker might not be satisfied that all valuable information had been extracted from these experiments, but the gas engineer was now at least in a position to supply gas free from gum.

An interesting sequel is found in a subsequent study of the formation of the gum particles and the disappearance of nitric oxide under conditions more like those which actually existed in a working gasholder—that is to say, the mixture in the holder is in active reaction while a stream of new, unreacted gas is entering and reacted gas is leaving simultaneously. (Badger and Dryden, *Trans. Faraday Soc.*, 1939, **35**, 607.)

A very remarkable series of events results. The new gas reacts quickly, depositing its resultant gum on to the already existing gum particles which first grow larger and then settle out by condensation of moisture from them. After a time the reacting gas, finding it has not enough nuclei on which to deposit its newly formed gum, builds up a concentration of potential gum well above the saturation point, and at this stage a fresh fine cloud of minute particles is formed by condensation on ions always present in the gas. The former cycle of events is now repeated, the gum particles growing and settling until the new gas formed has to create its own gum particles, and the whole cycle is repeated.

Development

The distinction between research and development is qualitative rather than precise. Development might reasonably include all stages from the discovery of new ideas in a laboratory up to the point of putting to work the first full-scale plant and also the critical examination and experimental modification of full-scale plants to improve efficiency It would be difficult to realise these objectives without introducing some of the aims and methods of research. Design represents the satisfactory conclusion of all that has gone before, and should contain little or nothing that is experimental or uncertain.

Some industries segregate laboratory research from process development instead of allowing them to develop side by side. In the researches into gum which have been described, scientific personnel involved had a good working knowledge of gas production, purification, and storage, and the solutions which they finally propounded were such as they knew to be practical, and for which they were prepared to produce the required design.

This was a problem brought back from the operational field into the laboratory. When a process is passing from the laboratory to the full scale, the research worker can often with advantage accompany his project through all its stages, bringing back to the laboratory any problems found still to need elucidation.

There will usually be available a range of pilot-scale equipment, or it may be decided to build and operate a special pilot-scale plant. This will provide the first assessment of predictions made in the laboratory, and many problems will now reveal themselves for the first time. The pilot plant will normally afford means of measurement and control of variables in excess of what will be possible on the full scale. and one of the aims will be to establish as completely as possible the design data necessary for further progress. The outlook is still basically that of the research laboratory, and the stakes are small, so that failure costs little more than the time and the hopes of those who have worked in vain.

The critical moment arrives when it is decided to build the first production unit. At this stage the chemist and the engineer meet as equal partners in the enterprise. They must now attempt to reconcile conditions determined in the laboratory, or on the pilot-scale plant, with the necessity to construct a full-scale plant in a practical and economical way. The research worker will discover that engineers have deep seated and curious prejudices about the safety of plant and men working on them, and the engineer finds himself faced with problems of design which may at first appear to be put forward for no better reason than to tax his ingenuity and his patience. Each will learn something from the attempt to meet the other's requirements, and, of course, much of what is finally done will be in the nature of a compromise between the two points of view. Both will be aware that large sums of money are now at stake and that modifications which have to be made after the plant is completed or at work can be very costly and unsatisfactory. Failure is unthinkable (but, of course, not unknown).

Advances Through Chemical Engineering

Only comparatively recently has it been possible to make this passage from laboratory to full-scale plant with anything like certainty, a development made possible by the emergence of chemical engineering as a science in its own right during the last 50 years. Although great advances were made in many branches of chemical technology, and of course in the gas industry also, during the nineteenth century, they depended on individual skill and experience and the plant and operations involved tended to be associated only with single sections of industry.

Chemical engineering made its greatest advances where practical results could be successfully related to basic scientific data. Plants can always be designed and built where sufficient accumulated experience is available (the answer to 'How?'); the work will proceed far more quickly and with certainty when the data used have been correlated with fundamental physical properties (the answer to 'Why?'). The methods evolved need not be reserved for the professional chemical engineer but are available also as tools in the hands of research chemists and plant designers.

The more obvious successes have been scored in industries concerned with the processing of gases and liquids. This is the result of advances made in the treatment of fluid flow, which stemmed from the pioneer work of Osborne Reynolds. Reynolds first demonstrated the discontinuity which occurs when stream line flow changes to turbulent. Then for flow generally it was shown that out of the great number of variables involved four could be extracted and treated together in the familiar group

$$Re = Dus/\eta$$

where D is the diameter of the pipe (or equivalent for ducts) and u the velocity, s the density, and η the viscosity of the fluid, all expressed in consistent units.

Fluid Friction and Convection

The significance of this group in relation to fluid friction has been demonstrated over a very great number of observations, and forms, of course, the basis of the calculations of distributing engineers.

Reynolds also pointed to the analogy between fluid friction (transfer of momentum) and convection (transfer of heat), and correlations suitably based on the Reynolds number bring a considerable degree of order into a mass of data in this field. This treatment was later extended to absorption (transfer of material), for example, in the washing of gases by liquids or the evaporation of liquids into gases. Due to the complexity of the scrubbing surfaces normally used, and the presence of liquids flowing over

these surfaces, results are by no means as easily interpreted as those for friction in pipes, but once again a degree of order is introduced where some at least of the basic principles are understood.

The development of a process for removing sulphur compounds and recovering benzole from coal gas provides an example of how it is sometimes possible to use these methods and to proceed direct from the laboratory and the drawing board to the construction of a full-scale plant. The process involved the circulation of three times as much oil as is normal for benzole recovery, and in order to keep down the cost of operation it was necessary to supply adequate means of heat exchange and to strip the oil under vacuum.

Where the necessary design data were not available in any one of the operations involved, it was usually possible to carry out control experiments in the laboratory, which could then be transferred to the full-scale design by applying the experience of other operations—for example, ammonia washing, which had been more completely investigated (Silver, *Trans.Inst.Chem.E.*, 1934, **12,** 64). Other design points were checked by reference to tests on existing plants of orthodox design.

The plant was completed and put to work on a scale of 8 mill. cu.ft. per day and stayed at work, fulfilling its designed performance figure. (*Trans.Inst.Gas E.*, 1937/38, **87,** 288.)

It is exceptional to proceed so far in one stage and would indeed be unwise where high temperatures or chemical reactions are involved. The more usual procedure would be to advance by steps of five to 10 times in the scale of operation, through the pilot plant and a production prototype.

Design

There is a still lower degree of certainty in connection with the fundamental process of gas-making. The handling of solids which are subjected to high temperatures and are undergoing decomposition probably presents as difficult a problem as could be imagined, and it is natural that changes and modifications of design have proceeded with extreme caution. It has taken some 20 years of hard-won experience to establish the necessity for continuous taper in the minor axis when carbonising certain kinds of coal in continuous vertical retorts.

All this applies with equal force in an intermittent process such as water gas. The fundamental reactions of the fuel bed are well understood, but the problem of handling the solid residue of clinker is still one for which the solution is found in custom or expediency. Although the mechanical grate in one or other of its forms deals satisfactorily with most situations, we are left with a great respect for the good sense of blast furnace operators who permit their clinker to flow away in an easily handled molten slag.

Some interesting points of design have emerged in the course of the work which I have described, and they are mentioned here in the hope that they may stimulate interest in the everyday plant at our works.

Gas Washing.—Where the liquid to gas ratio is high, say 8 gall. per 1,000 cu.ft., grid-packed tower scrubbers provide the best form of washer. The gas industry very properly developed an extreme distaste for tower scrubbers as a result of their unfortunate misuse in connection with ammonia washing. The monumental specimens which litter our older works are in many cases many times too large in diameter to give a reasonable gas velocity. Even the narrowest scrubber which back-pressure conditions permit would be too large in cross-section to allow the water (1 gall. per 1,000 cu.ft.) to be distributed so as to wet the whole of the packing. The rotary washer and its successor, the static washer, was a brilliant solution of this quandary but need not be pressed into service for which it is not best fitted.

Stills.—The function of a stripping still is to contact steam as intimately as possible with oil, and the steam must therefore be broken into as many fine streams as possible. The simplest way to do this is to have a large number of bubble caps, each of which is quite small, and with many slots formed in its side. Some examples of stills frequently used in the gas industry seem to pursue quite different objectives.

Water Supply.—A chimney-type cooling tower was bought to specification and had to be converted to forced draught before it would perform the required duty. This led to a series of interesting investigations. It was difficult to understand why:—

(1) A presumably permanent structure is built of timber. Machinery is no longer housed in timber shacks.

(2) Sheet metal fans incapable of a higher efficiency than about 25% were still being used when the effectiveness of aerofoil section had been recognised for 20 years.

(3) The packing was of a form designed to create splash rather than to provide a surface for the transfer of water vapour to the air in the tower.

By following simple rules of chemical engineering a distinct improvement in efficiency of operation has been achieved.

Pumps.—Almost all pumps seem to suffer from chronic gland trouble. It was necessary to extract hot oil from a vacuum of 20 in. of mercury and pump it up to a pressure of 100 lb. per sq. in. The multi-stage centrifugal pumps made no difficulty of this task after the gland on the suction side had been supplied from an independent source with cold oil fed on to a lantern ring at a moderate pressure. Until this was done it was impossible to start up the pump without drawing in air, which caused a series of locks in each subsequent stage.

Liquid Coolers.—The unattractive looking cast iron rack coolers which are so familiar a sight, constitute an extremely well proportioned and efficient design, provided that the velocity within the tubes is high enough and someone will take the trouble to see that they are kept reasonably clean on the outside, and that the water is distributed uniformly and at a large number of points on the top tube so as to ensure a continuous film of water all over.

Steam and Power.—A beam engine installed in 1866 to drive an exhauster, though not much used in recent years, is still in good working order. The engine is compound and condensing and so remains a much more efficient machine than most steam engines installed for similar purposes in the last 40 years, as the unsightly plumes of exhaust at many works will testify. If non-condensing steam engines must be used, it is worth while to give as much care to the useful disposal of exhaust as to the supply of live steam. At one works (already efficient by all other standards) where this was done, a further saving was made of nearly half a hundredweight of boiler fuel per ton of coal carbonised. No further research or development is required for this kind of improvement.

These random examples have been chosen to show how the final result of research and development can appear in the form of a finished piece of plant which offers itself for critical examination—not only as to its immediate value but, what is more interesting, as to whether it has fulfilled in the best possible way the basic principles for which it has been evolved. This attitude of critical examination, and the enquiring mind which is prepared to search out underlying causes, can enliven the day's work with benefit both to the individual and to the industry.

Conclusion

If the title of this paper has given the impression of a wider field than it has proved possible to cover, apologies are due to those whose interests lie in the sales and service side of the industry. For reasons of personal preference and because it happens that these were the things with which I am best acquainted, my examples have been chosen from the field of gas manufacture. The principles, however, are the same, and the industry's publications give evidence of an equally active urge to improvement and development in the design and performance of appliances in which gas is used.

(A brief record of the discussion is held over)

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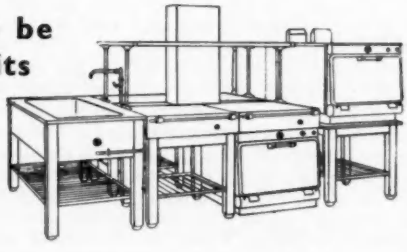

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IN PARLIAMENT

Fuel Efficiency Loans

Mr. G. Nabarro (Con., Kidderminster), valiantly riding his hobby-horse, enquired of the Minister of Fuel and Power what steps he is taking to amplify the fuel efficiency loans scheme. The Parliamentary Secretary, Mr. Joynson-Hicks, answered that loans can now be considered for proposals which relate to non-industrial as well as to industrial schemes—provided they are calculated to save substantial amounts of fuel and are not required for 'replacement of equipment necessitated by wear and tear.' Mr. Nabarro followed with another question—whether the Minister had completed his survey of industrial steam usage with a view to promoting further employment of back-pressure turbines. Mr. Joynson-Hicks explained that the survey was nearly completed and would be published in a few months time in the Ministry's Statistical Digest.

Air Pollution

On March 10 the City of London (Various Powers) Bill was read a second time in the House of Commons. The main purpose of the comments by Sir Herbert Williams (Con., Croydon East) was to obtain a debate on air pollution. Fifteen months ago a major tragedy had taken place in the Metropolitan area, caused by the strange atmospheric condition at that time. Something like 4,000 deaths had resulted from it in five days, equal to one-tenth of the total bombing casualties over six years of war. He had consulted a number of doctors, chemists, fuel combustion experts, and others who might have information bearing on the problem, but he was satisfied that scientific knowledge at the moment was inadequate and that nobody had the answer. Investigation and research were needed, first to find out exactly where the danger lay, and, secondly, to find a cure for it.

The effect of prevailing wind was mentioned by Dr. B. Stross (Lab., Stoke-on-Trent, Central), who commented that, although the City of London was to clean itself up, the prevailing wind was such that the City would probably get less benefit than its neighbours. To get the best results a smokeless area was needed for Westminster, Fulham, Chelsea, and Kensington. The Government should force local authorities to act more quickly.

The suggestion was made by Sir Robert Cary (Con., Manchester, Withington) that the Government might allow a 15% discount on coke, to tempt people from the coal-burning grate to the new forms of smokeless coke-burning appliances.

If smokeless zones are developed alone, nothing much will be achieved. That was the view of Mr. S. Hastings (Lab., Barking). It was useful, he said, to have smokeless fuels, but too much should not be expected from them.

Sir Harold Webbe (Con., Cities of London and Westminster) said that the City of London sought the powers because it was embarking on the rebuilding of large areas, and it was the most appropriate time to establish a smokeless zone so that the new buildings could be made to prevent the emission of smoke. For many years before 1941, when the apparatus was destroyed by bombing, the City of London had kept regular checks on air pollution; in 1948 the City was able to re-establish their observation and testing stations. All that the City of London was asking was that they should be given powers to make a beginning.

Mr. A. E. Marples, Parliamentary Secretary, Ministry of Housing and Local Government, said that the issue was the narrow one whether there should be a smokeless zone in the City of London. The whole House would agree that there should be; and the Government hoped the Bill would go through. The Government, indeed, was determined to conquer the evil of air pollution generally. The intention was not lukewarm; it would be enthusiastic and keen. Carefully planned expansion of the smokeless zones would be welcomed. The Ministry of Fuel would encourage this expansion. It was estimated that there were 12 mill. houses with open fires—far too many if there were to be smokeless cities. The Government wished to install modern grates in the old houses and to ensure a steady supply of smokeless fuel. It proposed to persuade as many local authorities as possible to display for several months two or three improvements and conversions, including fuel-saving appliances, with details of their weekly running expenses.

Butane and Propane

The Ministry of Fuel and Power was asked what applications he has received for allocation of foreign currency for the purchase of butane-air plants as an alternative to gas manufacture in Wales; what reports he has received from the officers of his research department on the success of this development; and what further experiments with this supply he intends conducting in the rural parts of Wales.

Mr. Geoffrey Lloyd, in a written reply, stated that the Wales Gas Board had received licences to import three such plants from the United States and had also imported one plant from France under open general licence. The plants had so far proved satisfactory. The Board was now considering the installation of additional plants and was experimenting with the use of propane.

Atomic Energy

Consideration was resumed late on Wednesday evening of the Atomic Energy Authority (Money) Bill, and a resolution was carried authorising: (a) the payment out of moneys provided by Parliament of such sums in respect of the expenses of that Authority as the Lord President of the Council may with the consent of the Treasury determine; and (b) the payment into the Exchequer, if the Lord President of the Council with the approval of the Treasury so directs, of the whole or any part of the revenues of that Authority for any financial year.

AN AUSTRALIAN VISIT

Meeting of well known members of the gas industry at Sydney during the visit of Mr. Ivan Yates, Director of Radiation Ltd.

Gas Board Collier Sinks

The motor vessel *Guildford*, the latest addition to the fleet of colliers owned by the South Eastern Gas Board, was sunk after being in collision with the steamship *Temple Bar* about three miles off Whitby on March 10. There were no casualties. The *Guildford* was loaded with gas coal for London.

The stem of the *Temple Bar* contacted the port side of the collier in the vicinity of the bulkhead, between the engine-room and No. 3 hold, which made water rapidly. As the leakage in the engine-room was got under the control of the ship's pumps, after the arrival of a tug, it was decided to tow the vessel to the Tees.

Further tug assistance was sent, but at about 12.30 p.m., owing to the rush of water through the damaged bulkhead, the engine-room got out of control. After taking a severe list the stern sank in 5¼ fathoms at low water. The Whitby lifeboat had stood by the whole of the time the collier was in difficulties. The *Guildford*, which normally carried a complement of 17, completed its maiden voyage on February 1, 1953.

B.W.P.A. Convention

The 1954 Convention of the British Wood Preserving Association will be held at Trinity College, Cambridge, on June 22-25. The provisional list of papers to be presented includes: 'Requirements and Variations in Pressure Treatment,' by E. H. Nevard, Hickson's Timber Impregnation Co., Ltd.; a paper dealing with recent research work on creosotes, by Dr. R. E. Heiks (Battelle Memorial Institute, U.S.A.); a paper dealing with preservatives of the organic solvent type by Ira P. Hatfield (Monsanto Chemical Co., U.S.A.); a paper dealing with extractives and permeability by Sir John Simonsen; and a paper dealing with preservation from the architect's point of view, by C. S. White, F.R.I.B.A. (Ramsey, Murray & White).

Newcastle Tenants Prefer Gas

During 1953 there were 5,013 local authority houses completed in the area served by the Newcastle Division of the Northern Gas Board—more than in any other post-war year—and there were installed in these homes a total of 4,413 gas cookers, 4,387 wash boilers, and 917 gas fires. This evidence of the popularity of gas for cooking and washing among housewives on new council house estates was one of the points contained in a report given by Mr. J. E. White, General Manager of the Division, to a recent meeting of the Newcastle Consumers' Committee.

He said all previous records had been broken for appliances. The recently-introduced Northern water heater had exceeded all expectations and between November 21 and February 1 this year no fewer than 3,100 sink heaters were installed. The hired fire had been equally successful with 3,009 fitted from October 1 to February 1. During the recent freeze-up the Division had been provided with ample opportunities to establish a succession of new record outputs both in delivery and production. The maximum day's delivery had progressively increased from 67 mill. cu.ft. to 73.7 mill. cu.ft., while the daily production figure had risen from 64.7 mill. cu.ft. to just over 70 mill. cu.ft.

A maximum week's demand of 472.1 mill. cu.ft. had been fully met by a production output of 472.8 mill. cu.ft. and, in spite of a sustained peak demand lasting eight weeks at a higher level than the maximum week recorded last year, augmented pressures had been maintained. Maximum delivery for a Sunday occurred on February 7 at 61,023,000 cu.ft. Percentage increases of 6.43 and 12.8 had been recorded for January and February, respectively, the latter being equivalent to an average additional output per day of 7.2 mill. cu.ft.

'Broomwade' at Home and at Work

In the late 1890's a small private firm was started in High Wycombe—Broom & Wade Ltd.—and in the following 55 years the Company has developed and built up a reputation as one of the leading firms in the compressed air field. It is hard to find an industry in which compressed air is not used in some way or another and the equipment turned out at High Wycombe covers a multitude of fields.

No effort is spared in attaining first class production, and, to save both time and effort on the part of those interested in their work, Broom & Wade Ltd., have prepared two interesting films—one of which shows the works at High Wycombe and illustrates the care, attention to detail and research which goes into every compressor turned out, be it large or small. Broom & Wade manufactures are used all over the world, and the differing conditions of work and climate are all carefully studied and allowed for.

The second film shows Broom & Wade equipment actually at work in many industries ranging from the packaging of sugar to the raising of sunken liners.

London Juniors Visit Crawley

In spite of bad weather close on 100 members of the London and Southern Junior Gas Association mustered at Croydon on March 3 for a day trip to Crawley. The trip was planned so as to follow the route of the recently laid trunk main from the Waddon works of the South Eastern Gas Board to Crawley New Town and so give members an actual sight of the work described in the paper read by Mr. J. E. Steel on January 15, reported in the 'JOURNAL' of February 10.

After an inspection of the pumping plant at the Waddon works, members were conveyed by coach, and various stops were made en route to inspect control points and other items of particular interest. Lunch was taken at Redhill and the visitors were welcomed by the Deputy Chairman of the South Eastern Gas Board, Mr. R. S. Johnson, M.B.E. After lunch a stop was made at the Horley works, where further boosting plant was inspected together with the new holder, the erection of which has been commenced by Robert Dempster & Sons, Ltd. The coaches then proceeded to Crawley where, thanks to the co-operation of the Crawley Development Corporation, the party split up, one coach proceeding to the factory area, and the other to visit the housing estate. The factories tour ended at the works of the A.P.V. Co., Ltd., where tea was provided.

Sugg Lectures

By arrangement with the South Western Gas Board, a series of talks on the principle, application, and installation of 'Halcyon' space heaters, 'Sapphire' balanced flue heaters, and Sugg incinerators were given by William Sugg and Co., Ltd., to the sales and fitting staff of the Torquay Sub-Division recently. The initial lecture on 'Halcyon' heaters was given by Mr. P. Crawford Sugg in the Torquay showrooms. The subsequent talks at Paignton, Newton Abbot, and Brixham, were given by Mr. R. Boorn, assisted by the Area Representative, Mr. M. Hennessy.

The questions asked showed a keen and lively interest on the part of the audience, and illustrated the value of such talks.

Special Nalgo Conference

Because of dissatisfaction with recent salary awards, a special conference of the National and Local Government Officers' Association has been requisitioned by members. The conference will be held in London on April 3 to consider a motion tabled by the Stockport branch instructing the national executive council 'to take urgent and vigorous action to obtain a drastic revision' of present salary scales in all the public services covered by the Association. The Association has about 225,000 members in the local government, gas, electricity, national health, and road passenger transport services and the staffs of new towns.

In January the National Joint Council for the Local Government Service agreed to increases, ranging from £10 to £20 a year in the lowest to £25 in the highest grade, due to come into operation on April 1.

There have been similar increases in the electricity and gas services and a claim for the national health service is still under negotiation. The Association had claimed increases ranging from £15 in the lowest to £90 in the highest grade.

Change of Address.—The National Smoke Abatement Society has removed from Buckingham Gate to 30, Grosvenor Place, S.W.1. (The telephone number has not yet been notified.)

We Have the Brains.—Speaking on his return from a three-month tour of the United States, Mr. Alfred Robens, a former Parliamentary Secretary of the Ministry of Fuel and Power, said that if this country did not produce more high-quality goods at lower prices with the aid of more machines, we should go down. We had no need to: we had the brains, first-class workers, and we had been doing the job for years. We could do it only if we put more capital investments into selected industries.

Negotiations are to take place between Bangor and Newtownards Borough Councils regarding the posibility of an integration scheme for the production of gas supplies for the two towns. Discussions took place recently in Bangor between representatives of the two Councils, and the delegates from both bodies undertook to recommend their respective Councils to investigate the possibility of a scheme being carried into effect. Such a scheme might mean the closure of the Bangor gasworks and the production in the more up-to-date works at Newtownards of sufficient gas supply for the two areas.

PUBLISHERS' NOTICE

The " Gas Journal " is published every Wednesday, price 1/3d.; by post 1/5d.

Subscription Rates: Home and Empire:—52/- per annum; Foreign:—60/- per annum. (Both payable in advance.) A copy of the " Gas Journal " Calendar & Directory is presented each year to continuous subscribers.

Classified Advertisements: All small classified advertisements are charged at 1/9 per line (approx. 7 words)—minimum charge 10/6. A Box Number address occupies 2 lines, and a further 6d. is charged towards cost of postage on replies. Copy must be received by first post on Monday to ensure insertion in that week's Journal.

Displayed Advertisements: Rates obtainable on application to the Business Manager. Change of copy for displayed spaces must be received 14 days prior to publication if proofs are required. Type area of inside pages 10" deep × 7" wide: block screen 120.

BUSINESS MANAGER : S. T. CULLEN

MIDLANDS MANAGER: G. B. Torrance, 42, Wychall Lane, King's Norton, Birmingham, 30.

NORTHERN MANAGER: W. Q. Foster, 33, St. Helens Road, Harrogate. *'Phone:* Harrogate 84291.

WALTER KING, LTD., 11, Bolt Court, Fleet Street, London, E.C.4.

Telephone: CENtral 2236-7. *Telegrams:* Gasking, Fleet, London.

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SPECIALLY ACTIVATED OXIDE OF IRON

Oxide supplied on loan or sale outright.
Highest prices paid for Spent Oxide.

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ESTABLISHED 1873

PALMERSTON HOUSE, OLD BROAD STREET, LONDON, E.C.2.

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FIRE!

GENII GALORE IN EVERY

NU-SWIFT!

Sealed pressure charges explain the speed, reliability and efficiency of Nu-Swift Fire Extinguishers. Strike the knob—the genii instantly leap out to slay your fire!

NU-SWIFT LTD · ELLAND · YORKS

In Every Ship of the Royal Navy

"KLEENOFF" *

THE COOKER CLEANER

"KLEENOFF"

FIBRE BRUSHES
RUBBER MOPS

"KAY-DEE" *

KETTLE DESCALER

For resale to the public, and in bulk for Works use.

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BUFFALO EJECTOR

For pumping water or other liquids.

Send for List:—

GREEN & BOULDING, LTD.

162a Dalston Lane, London, E.8

APPOINTMENTS VACANT

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

THE PARKINSON STOVE CO., LTD. invites applications for the progressive post of SALES REPRESENTATIVE. Preference will be given to applicants who are well known in the South of England. Applicants must be of good appearance, education and personality. The position is a permanent and pensionable one. Letters, in confidence, stating age, qualifications, experience and salary required to be addressed to the Personnel Manager, Iron Lane, Stechford, Birmingham, 33.

EAST MIDLANDS GAS BOARD

HEADQUARTERS

SENIOR ASSISTANT—

DISTRICT RESEARCH CENTRE

APPLICATIONS are invited from suitably qualified persons for the above appointment in the Commercial Manager's Department. The successful applicant will be required to work in the District Research Centre at Syston near Leicester. The work of the Centre covers the assessment of district performance of domestic gas and coke appliances, fittings and meters. Possession of a university degree or its equivalent would be an advantage.

The appointment will be made in the first place within Grade A.P.T. IX of the National Salary Scales for Gas Staffs, £635-£735 per annum).

The successful candidate may be required to pass a medical examination and unless already subject to a pension scheme by virtue of the Gas (Pension Rights) Regulations 1950, may be required, if eligible, to join the Board's Staff Pension Scheme within six months from taking up the appointment.

Applications stating age and giving details of qualifications and experience together with the names of two referees should be addressed to reach the undersigned not later than Saturday, April 3, 1954.

A. GWYNNE DAVIES,
Secretary.

Beverley House,
University Road,
Leicester.

SOUTHERN GAS BOARD

CENTRAL DIVISION

READING & DISTRICT GAS UNDERTAKING

APPLICATIONS are invited for the position of SHIFT SUPERINTENDENT at the works of the Reading and District Gas Undertaking.

Candidates should possess the Institution of Gas Engineers Higher Grade Certificate in Gas Manufacture, or equivalent qualification, and have experience in the operation of modern gas works plant.

Salary will be in accordance with A.P.T. VI (£510-£590 per annum) of the National Joint Council for Gas Staffs.

The successful candidate will be required to undergo a medical examination and to join the Southern Gas Board's Pension Scheme.

Applications giving full particulars to be lodged with the undersigned not later than March 27, 1954.

W. BELL, Esq.,
Group Manager.

King's Road,
Reading.
March 9, 1954.

SOUTHERN GAS BOARD

CENTRAL DIVISION

ALDERSHOT & DISTRICT

GAS UNDERTAKING

APPLICATIONS are invited for the position of DRAUGHTSMAN at the Aldershot Gas Undertaking. Candidates should have good Engineering Drawing Office experience. A knowledge of gas works plant and workshop training would be an advantage.

The salary for the post will be within Grade A.P.T. V of the National Salary Scales for Gas Staffs.

The post is pensionable and the successful candidate may be required to pass a medical examination.

Applications giving full particulars of age, experience and qualifications and giving the names of two referees to be submitted to the undersigned on or before March 27, 1954.

D. RITCHIE, Esq.,
Group Manager.

235, London Road,
Camberley,
Surrey.
March 9, 1954.

SOUTHERN GAS BOARD

CENTRAL DIVISION

ALDERSHOT & DISTRICT

GAS UNDERTAKING

APPLICATIONS are invited for the position of SENIOR DRAUGHTSMAN at the Aldershot Gas Undertaking. Candidates should have good Engineering Drawing Office experience. A knowledge of gas works plant and workshop training would be an advantage.

The salary for the post will be within Grade A.P.T. VII of the National Salary Scales for Gas Staffs.

The post is pensionable and the successful candidate may be required to pass a medical examination.

Applications giving full particulars of age, experience and qualifications and giving the names of two referees to be submitted to the undersigned on or before March 27, 1954.

D. RITCHIE, Esq.,
Group Manager.

235, London Road,
Camberley,
Surrey.
March 9, 1954.

(*Classified Advertisements continued on page* 698)

APPOINTMENTS VACANT (ctd.)

THE BRITISH COKE RESEARCH ASSOCIATION invite applications for the following posts:—

(*a*) One Senior Scientific Officer (Salary range £886-£1,033).
(*b*) One Scientific Officer (Salary range £418-£781).
(*c*) One Experimental Officer (Salary range £650-£800).
(*d*) Two Assistant Experimental Officers (Salary range £264-£576).

The work involved will be in the nature of operational research and connected with the study of practical problems related to coke ovens, blast furnaces and foundries. The duties will comprise work in different locations from time to time, mainly in the Yorkshire, Midland and South Wales Coalfields.

For posts (*a*) and (*b*) applicants should be Honours graduates or equivalent. Some knowledge of statistical methods would be an advantage. For post (*c*) applicants should possess pass degree, higher national certificate or equivalent qualification.

Applications stating age, education, training and experience should be addressed to the Director, British Coke Research Association, 74, Grosvenor Street, London, W.1.

NORTH WESTERN GAS BOARD

NORTH CHESHIRE GROUP
DISTRICT SERVICE MANAGER—
MACCLESFIELD DISTRICT

APPLICATIONS are invited for the above pensionable appointment at a commencing salary of £900 per annum.

The person appointed will be responsible for all aspects of consumer service within the above district, including the organisation of gas installation and maintenance staffs, the control of showrooms and general administrative co-ordination.

Detailed applications, giving the names of two referees, should reach the General Manager, North Western Gas Board (North Cheshire Group), Great Portwood Street, Stockport, within fourteen days.

NORTH WESTERN GAS BOARD

MANCHESTER GROUP
CARBONISING ASSISTANTS—
SALFORD AND PARTINGTON WORKS

APPLICATIONS are invited for the above pensionable appointments at salaries within Grade A.P.T. VI (£510-£590 per annum).

Applicants must have had experience in the maintenance, operation and efficient working of all types of carbonising plant and they will be required to carry out their duties under the direction of the Carbonising Superintendent.

Detailed applications, giving the names of two referees, should reach the General Manager, North Western Gas Board (Manchester Group), Town Hall, Manchester 2, within fourteen days.

NORTH WESTERN GAS BOARD

ENGINEERING DRAUGHTSMEN

APPLICATIONS are invited for the above pensionable appointments in the Liverpool, Manchester and Stockport districts at salaries within the range of £565-£685 per annum.

Applicants should possess a sound engineering training and be experienced in the design and construction of gas works or chemical plant, including building construction, steel structures, foundations, etc. Experience in the design and layout of steam, electricity and water services would be an advantage.

Detailed applications, giving the names of two referees, should be sent within fourteen days to :—

Liverpool Vacancy ...	Chief Personnel Officer, North Western Gas Board (Liverpool Group), Radiant House, Bold Street, Liverpool, 1.
Manchester Vacancies	General Manager, North Western Gas Board (Manchester Group), Town Hall, Manchester, 2.
Stockport Vacancies	General Manager, North Western Gas Board (North Cheshire Group), Portwood Gasworks, Stockport.

MAINLAYING AGENT required by old established Firm of Civil Engineering Contractors, to supervise and take complete control of several Mainlaying Gangs in Home Counties. Applicants must have a very thorough knowledge of Gas Mainlaying and be capable of turning out really first class work. A knowledge of Water Mainlaying also would be an advantage. Car provided and Superannuation scheme available after probationary period. Write in first instance, stating experience, salary and expenses required to No. 185, *Gas Journal*, 11, Bolt Court, Fleet Street, London, E.C.4.

SCOTTISH GAS BOARD

LANARKSHIRE DIVISION
HAMILTON DISTRICT
STATION ENGINEER

APPLICATIONS are invited for the appointment of STATION ENGINEER at the Hamilton District Undertaking.

The successful applicant will be responsible for the production of gas and residual products and the maintenance of the carbonising and ancillary plant at the Hamilton Station of the Lanarkshire Division.

The appointment carries a salary of Provincial 'A', A.P.T. VIII/X—£605-£790 per annum with placing according to qualifications and experience. If required, a rented house may be provided.

Candidates should be Corporate Members of the Institution of Gas Engineers and should be fully experienced in the control of modern Gas Works Plant.

Applications, appropriately endorsed, giving the names of two referees and full particulars of education, training and experience should reach the undersigned not later than Monday, March 29, 1954.

JAMES M. DOW,
Divisional Controller.

Divisional Offices,
Bothwell Road,
Uddingston.
March 3, 1954.

RESEARCH SCHOLARSHIPS

THE GAS COUNCIL

RESEARCH SCHOLARSHIPS

THE GAS COUNCIL invites applications for five RESEARCH SCHOLARSHIPS from graduates or prospective graduates in physics, chemistry or engineering at British Universities. The scholarships will be awarded for a period of three years from the 1st September, 1954, and the Universities in which they will be tenable are as follows :—

University of Oxford ...	Departments of Chemistry.
University of Cambridge...	Department of Chemical Engineering.
University of London ...	Department of Chemical Engineering at either the Imperial College of Science and Technology or University College.
University of Birmingham	Department of Chemical Engineering.
University of Glasgow ...	Department of Chemistry.

The subject proposed for research must afford scope for original work and be of a character approved by the Research Committee of the Gas Council which is interested in problems related to the manufacture, distribution or use of gas. Each scholarship will carry an allowance at the rate of £350 a year together with the payment of University and College fees.

Particulars and application forms may be obtained from the Secretary, the Gas Council, 1, Grosvenor Place, London, S.W.1, or from the Head of any one of the University Departments named above. Applications should be submitted on or before March 31, 1954, to the Secretary, the Gas Council, or, if the candidate is a student in one of the University Departments named above, to the Head of that Department.

March 5, 1954.

PLANT FOR SALE

GAS HEATERS. The Margate Corporation have for disposal the following overhead interior gas heaters.

26 Bratt Colbran Luminous Panel Heaters.
7 Bratt Colbran Wedge Pattern Heaters.

Offers should be submitted to the Entertainments Manager, Winter Gardens, Margate, where the above may be inspected. The Corporation do not bind themselves to accept the lowest or any offer.

T. F. SIDNELL,
Town Clerk.

PUBLICATIONS

GAS ACCOUNT CALCULATORS

SUPPLIED either by Price per Therm or Thousand, for any specified Calorific Value, in book form, office charts, or pocket charts for Meter Inspectors, printed in clear type. Write for particulars to F. H. WAKELIN, LTD., Calculator Specialists, 354, WHEELER STREET, BIRMINGHAM.

'Phone: Northern 0989. 'Grams: Reckoners, B'ham.

MISCELLANEOUS

SMALL single truckloads and larger quantities of good ROUGH BREEZE from any gasworks, large or small, in the United Kingdom required by merchants paying own railway tolls. Cash price and particulars to : No. 9378, *Gas Journal*, 11, Bolt Court, Fleet Street, London, E.C.4.

MOISTURE TESTING for coal, coke and ash and many chemicals. Modern method is 'SPEEDY' MOISTURE TESTER giving accurate percentage water in 2/3 minutes. Already in use extensively in Gas Industry. Needs no electricity. Portable, simple for use by unskilled labour. Write for illustrated brochure, or order direct, £24 10s. Od. complete.—Thos. Ashworth & Co., Ltd. (Dept. G.J.), Basket Street, Burnley, Lancs.

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interest in a given commodity and enhance the potential of the Sales Staff. They can be used in a far more realistic way than black and white photographic prints to show off heavy machinery or a factory site. Understanding of blue-prints, service manuals, and the arrangement of complex machinery, cabling, piping, and lagging, to mention but a few examples, is made straightforward with the aid of 3-D colour slides. The foregoing remarks are addressed to the go-ahead Sales Managers, Maintenance Equipment Officers, P.R.O.s, and Publicity Managers. It will not cost them more than a 'phone call or a 2½d. stamp to find out more about this medium which is an up-to-date rendering of a very old principle. Enquiries to : **Walter King Photography, 11, Bolt Court, London, E.C.4.**, who are always in the lead with the latest developments of photography. And to firms whose policy it is to present regular pictures by means of projected slides, we have also something to offer—on 3-D lines of course!

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A SPEEDY SERVICE

Sell to those best suited to deal with them.

TOP PRICES PAID

Collection arranged from anywhere in U.K. Truck Loads to our own private siding, Beddington Lane, Southern Region.

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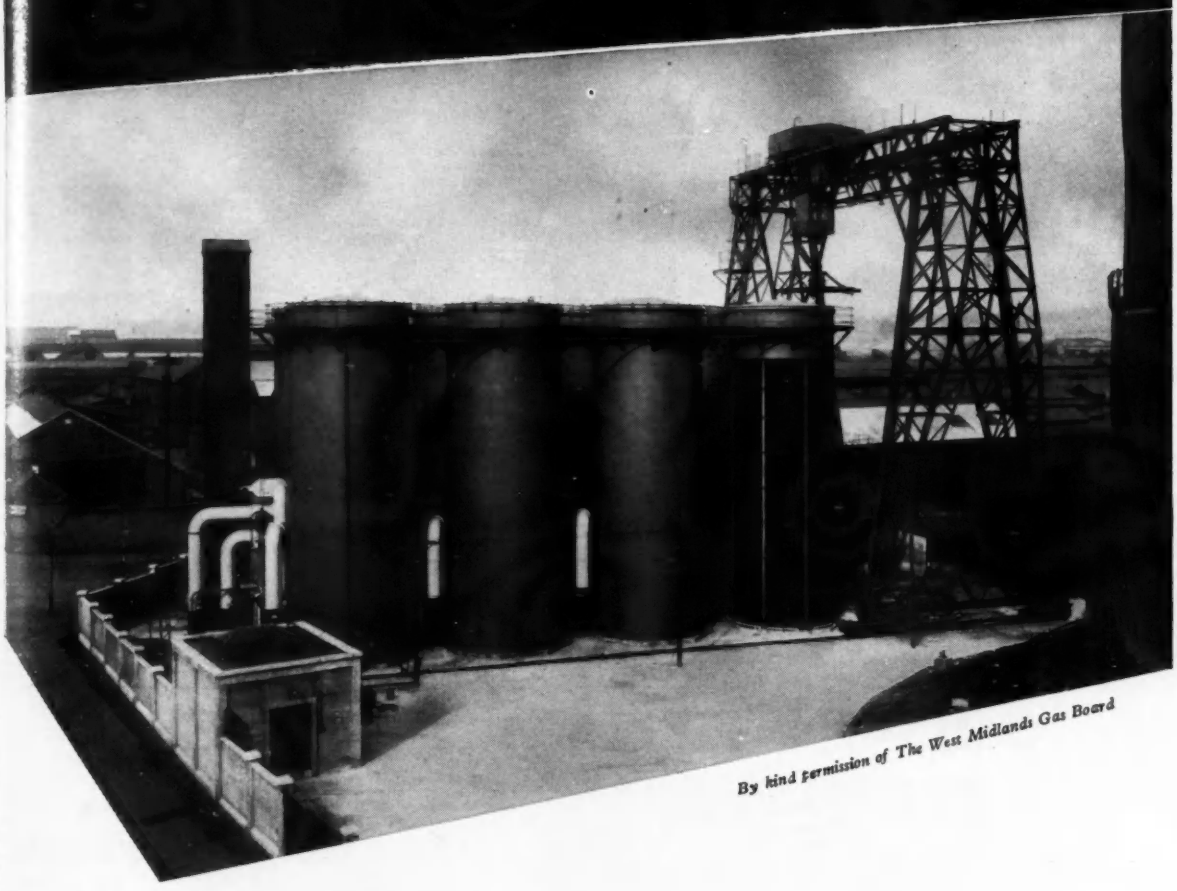

By kind permission of The West Midlands Gas Board

A tight corner...

The Tower Purifiers above are installed on a long, narrow site between a Gasholder and the Works boundary. The Towers are placed at one end of the site. A covered space at the other end, with plant for mechanical loading and mechanically assisted unloading of containers, ensures smooth and easy handling of oxide.

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we serve to burn

"Fishtail" type burner *with two-armed stamped pattern injector for heating liquid in tanks by submerged horizontal combustion tubes. For use with low pressure gas supplies.*
Size Range: *1", 1¼", 1½", 2" and 2½" outlets.*
Capacity Range: *45-280 cu. ft. of gas per hour.*

Note.—These four burner heads are for high pressure gas or low pressure gas and air blast.

Brass non-blow-off head types: *deal with 5 to 10 cu. ft. of gas per hour.*

Stainless steel, "F" type head, burner: *deals with 8 cu. ft. of gas per hour.*

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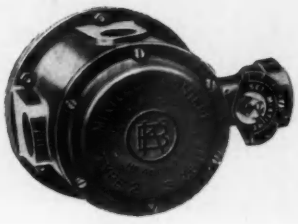

Type 2 Mixture Controller, *for controlling quality of air/gas mixture irrespective of varying pressures and resistances. Temperature control is varied by manipulation of the air cock only.*
Capacity Range: *from 130 to 1380 cu. ft. of gas per hour according to air pressure (¼ lb. to 1lb.) and size. For low pressure gas systems.*
Air Inlets: *1", 1¼", 1½" and 2" diameters gas thread.*

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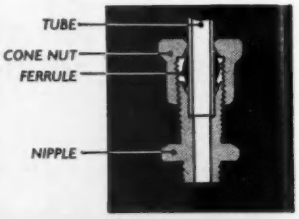
DID YOU KNOW?

KEITH BLACKMAN have been making compression joints for many years and the present design embodies features developed as a result of this long experience. Notice that the shape of the ferrule is such that the joint is made without unduly stressing the tube.



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510

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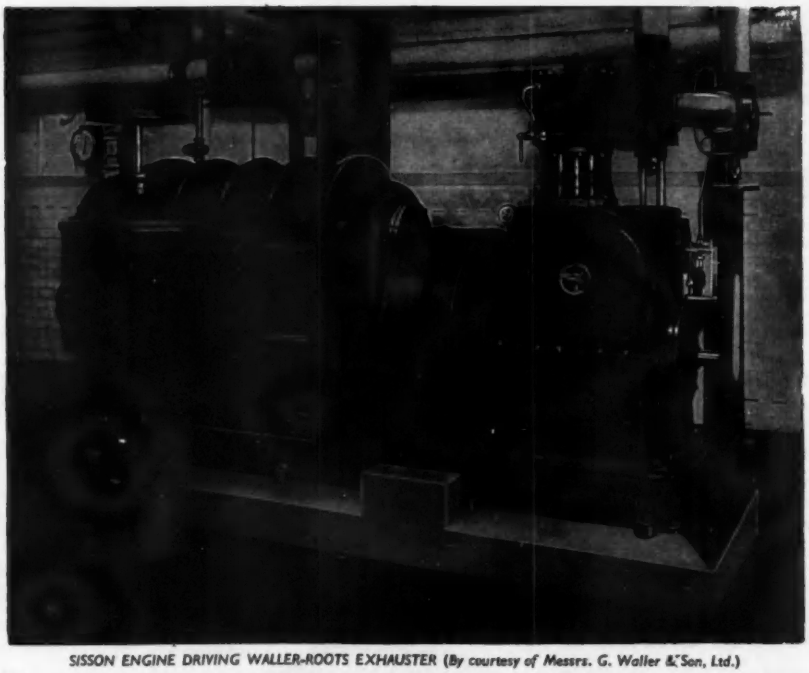
DESIGNED for driving EXHAUSTERS BOOSTERS COMPRESSORS ETC.



DEPENDABLE for NON-STOP DUTY SUITABLE for GAS GOVERNOR or AUTOMATIC CONTROL

SISSON ENGINE DRIVING WALLER-ROOTS EXHAUSTER (By courtesy of Messrs. G. Waller & Son, Ltd.)

Telegrams:— SISSON. **W. SISSON & CO., LTD. Gloucester, Eng.** Telephones:— 22295-6.

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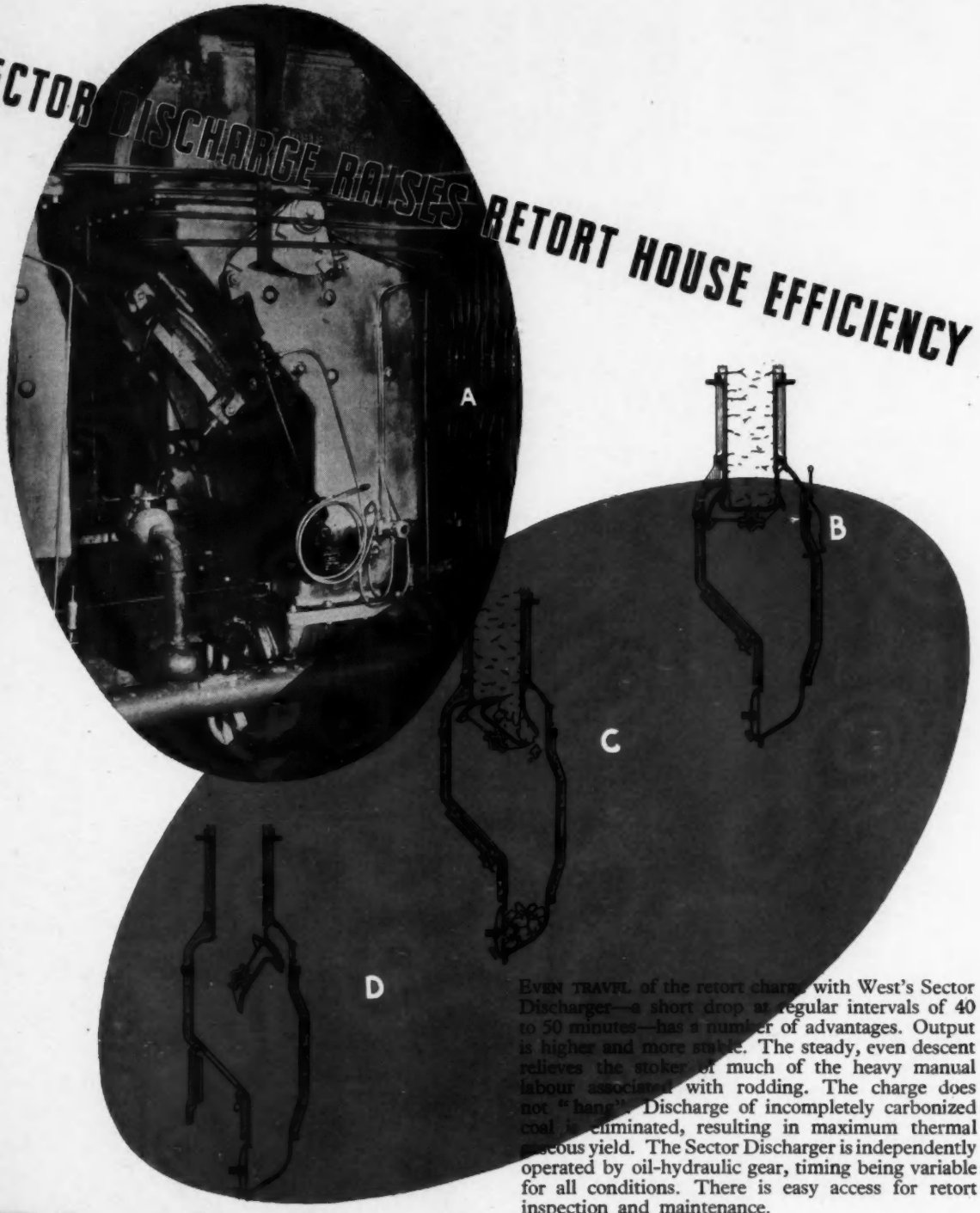
SECTOR DISCHARGE RAISES RETORT HOUSE EFFICIENCY



EVEN TRAVEL of the retort charge with West's Sector Discharger—a short drop at regular intervals of 40 to 50 minutes—has a number of advantages. Output is higher and more stable. The steady, even descent relieves the stoker of much of the heavy manual labour associated with rodding. The charge does not "hang". Discharge of incompletely carbonized coal is eliminated, resulting in maximum thermal gaseous yield. The Sector Discharger is independently operated by oil-hydraulic gear, timing being variable for all conditions. There is easy access for retort inspection and maintenance.

Illustrations: A. Exterior view showing oil-hydraulic drive. B. Discharger at rest. C. Operating. D. Access position for inspection of empty retort.

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